MECHANICAL ENGINEERING

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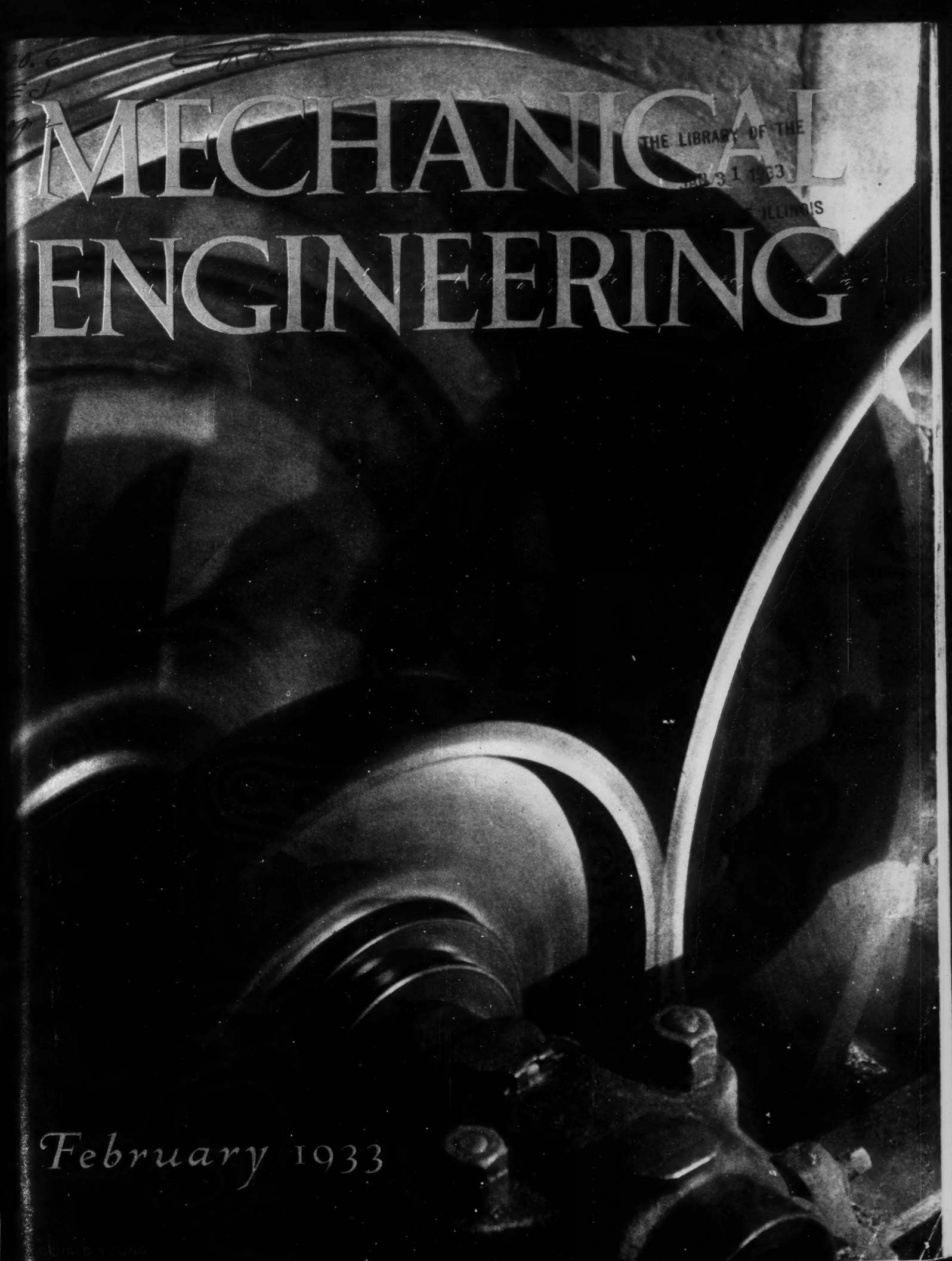
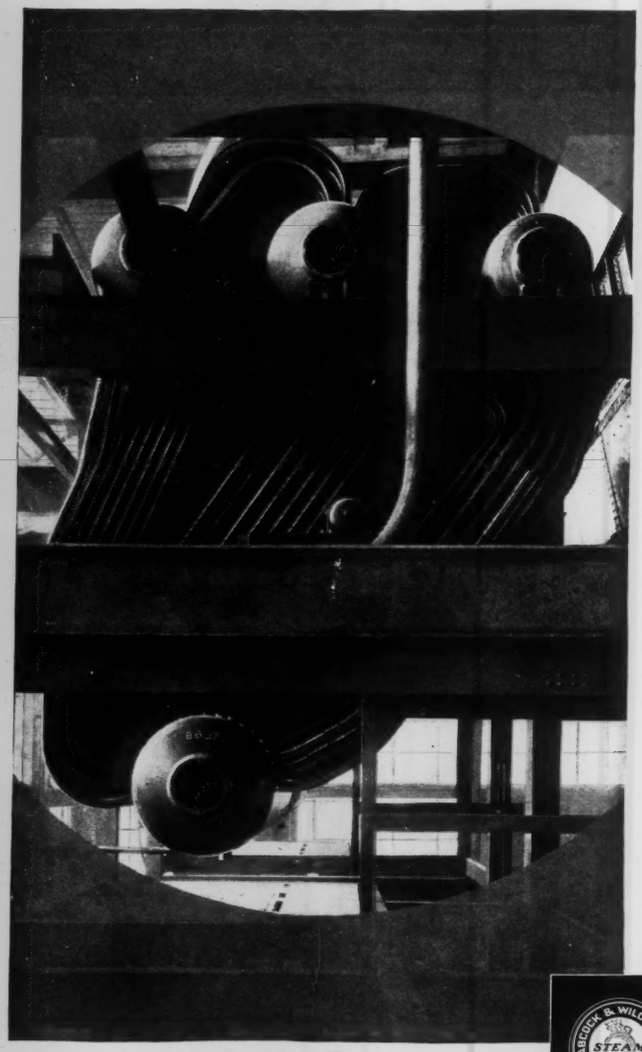


February 1933

Introducing---

a new and striking development in boiler-drum construction



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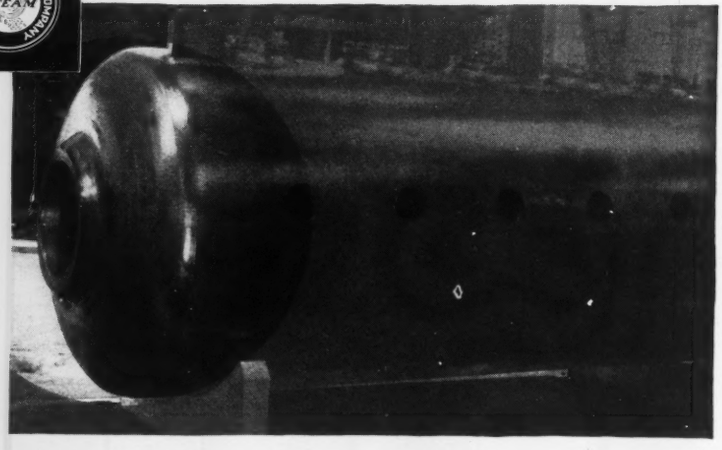

Above . . . an erection view of one of four Stirling Boilers at a colliery of a large coal company. This installation features the first use of boiler drums with integral spun heads in this type of boiler.

At the right . . . a close-up of a Babcock & Wilcox Boiler Drum of this construction shows the smooth contour of the head.

MECHANICAL ENGINEERING

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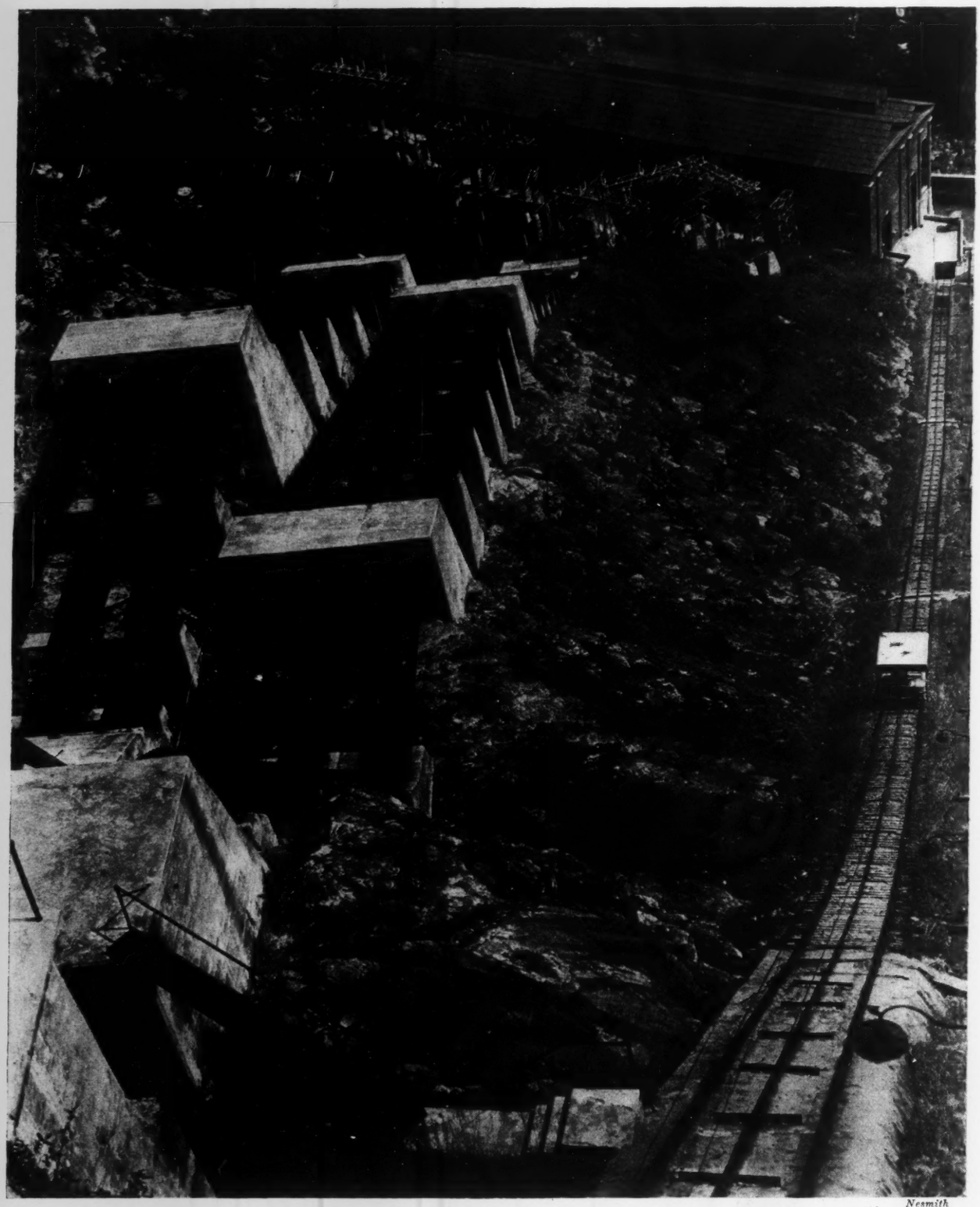


Power From the Hills to Serve the Homes and Industries of the South

Recent Advances in PHYSICS

By W. F. G. SWANN[1]

Physics is now well launched upon the next great stage of its attack upon the mysteries of nature. The nucleus has withstood assault for many years, but in the experiments of Cockcroft and Walton the physicist has tasted the blood of conquest. Bigger guns are being built for the attack, and who knows but that in time we may realize in a practically usable sense the dream of the alchemists, the transmutation of the elements, and with it the still more dramatic hope, the utilization of atomic energy in the service of mankind.

IT IS A CHARACTERISTIC feature of the march of progress in natural philosophy that from time to time we seem to reach a stage in which the horizon of discovery is also its boundary. Nature seems to divide her phenomena into two categories, those concerning which we seem to know everything, and those of which we can never know anything. The reason for the existence of these dark periods when the hope of further discovery seems to have died forever is, I think, not far to seek. When the phenomena revealed in a certain epoch have been correlated into some successful scheme by which we understand the relations of those phenomena, that very scheme itself tends to bar to our vision realms of truth which may lie outside. The so-called laws of nature, chosen originally with conformity to the facts as the sole criterion for their truth, seem to claim a position of fundamentality of their own which almost threatens to bar further facts. The glories of a more complete revelation stand completely obscured from a field of knowledge which seems consistent in itself without them, unless they have in that field a sufficient number of representatives to claim attention.

The end of the last century witnessed the discovery of radioactivity, of X-rays, and of the electron. Soon the photoelectric effect made its appearance, and physics found itself possessed of a new set of phenomena lying outside of the immediate realm of the spirit of the philosophy of Newton, Faraday, and Maxwell. Most of these phenomena are characterized by the fact that they do not spontaneously make themselves evident. Man has to do something to produce them. Even then the phenomena themselves are of such rarity from the point of view of the individual atoms that hardly any designation less drastic than a miracle is fit to describe them. The photoelectric effect is a phenomenon of the atom. Yet if you lived on an atom, participating in what might be called the natural pace of the atom, it is probable that you would be put in an atomic lunatic asylum if you maintained that such a thing as the photoelectric effect could ever occur. Similar remarks apply to the emission of X-rays, and indeed to most of those phenomena of fundamental interest in atomic physics.

ENDEAVORS TO EXPLAIN THE NEW PHENOMENA OF ATOMIC PHYSICS

It was natural to endeavor to correlate these phenomena with each other and with the past through the medium of the theories of the past. It was natural to seek an explanation of electrons shot out from metals by temperature agitation on the same lines as those which satisfy us in thinking of a football kicked through a window. It became natural to see these electrons bouncing off our apparatus as rubber balls would bounce from the ground. It became natural to seek an understanding of the effect of light and X-rays upon electrons in a way similar to that in which we feel we understand the action of a wave of the sea in imparting motion to a boat floating on its surface. We were fortunate and successful in many of these expectations. Had we been completely successful, progress would to a large extent have ended. The phenomena of nature would have divided themselves into two classes: those which were uninteresting, because they seemed to be the obvious consequences of the theory; and those which were of such a nature that, while not the obvious consequences of that theory, they were no more than the results to be expected by a sufficiently elaborate and laborious ferreting out of the consequences of the theory as applied to distressingly complicated cases. Happily or unhappily, as you prefer, however, experiment persisted in revealing a set of phenomena which seemed to constitute nonsense in the light of what appeared to be the natural way of doing things in the universe. And as our knowledge progressed these nonsensical things played an increasingly important part in the further development of physics, even in its practical and engineering aspect. Our common sense, that guiding spirit of the experiences of the past, which stimulates knowledge up to a certain point and then grips it by the throat as though it would say, "Thus far and no further shalt thou go"—that

[1] Director, Bartol Research Foundation of The Franklin Institute, Swarthmore, Pa.

Fifth Robert Henry Thurston Lecture on the Relation Between Engineering and Science. Delivered at the Annual Meeting of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, New York, December 8, 1932.

common sense suggested to us that the photoelectric effect should be seen as the wriggling of electrons out of atoms by light waves as the sea would wriggle apart the structure of a ship.

But nature revealed everything contrary to this view. The electron ejected had far more energy than could be accounted for by any such wriggling process. Moreover, a light wave striking a surface produced the photoelectric effect in only a few of the atoms here and there. In fact, in ejecting electrons the light acted more as a stream of widely spaced bullets would act. The theories of Maxwell and Faraday applied to electrons would have visioned X-rays as spreading ether pulses, initiated when electrons were accelerated or retarded. As was the case with light, however, the X-rays behaved in some of their most characteristic activities as bullets rather than as waves. On the other hand, there were those phenomena of classical optics, phenomena of the production of colors in thin films, phenomena concerned with colors which one sees on looking through his eyelashes or through a fly screen at a distant light, which demanded as insistently the wave explanation as the other phenomena concerned with the photoelectric effect demanded a corpuscular one. Then these wave-like optical phenomena were found to have their complete counterpart in the X-ray field, so that both light and X-rays cooperated in these villainous inconsistencies. The study of heat radiation had shown us that we must regard such radiation as traveling in definite units or "quanta," as they were called, in amounts proportional to what on the wave theory would be the frequencies of vibration of the waves. Even if the quanta were to be bullets, it was necessary to suppose that there were bullets of all sorts of different energies corresponding to the different possible frequencies of vibration on the wave theory. A consideration of certain optical features demanded that we should regard these quanta as of sufficient size in actual space extent to occupy a cubic meter or more of volume. On the other hand, the photoelectric effect and such phenomena required that they should have an extent in space which was little greater than the dimensions of an atom. In attempting to describe pictorially the nature of the quantum at this stage of our development, one could hardly do better than invent one of those word-twisting confusers of thought such as the following: "I am wider than a cartwheel, I am skinnier than a microbe; I am shorter than a yardstick, I am longer than a day's journey; I am bigger than a man, I am smaller than a flea. What am I?" Answer: "I am a quantum."

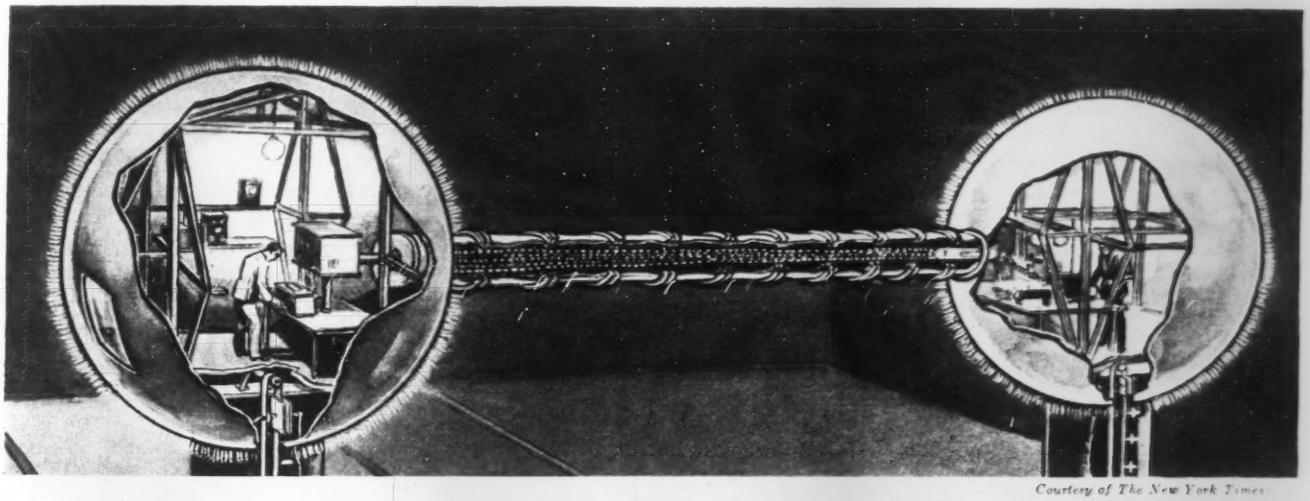
Then, as though nature had not been cantankerous enough in spoiling, by exhibition of the facts, the picture which man had made of her doings, she proceeded to add the last straw by causing the electron himself to exhibit phenomena which cast doubt upon his nature. This was terrible. The electron had always been the most respectable member of the atomic family. At least we thought we knew what he was. He was a particle if anything was a particle. He was the most fundamental of all particles. And yet a set of phenomena arose concerned with the reflection of electrons from metals which was much more easily understood by wiping out our pictures of particles and thinking of electronic phenomena as phenomena produced by waves.

The tendency in physics, as in everything else, is to hold on to the past. We dislike to think that the content of the past is not sufficient to embrace the future, and so we strive to strain the meaning of the past to fit that which follows. There comes a time, however, when the strain is too great. I have always been inclined to question the biblical instruction concerning the avoidance of placing a new patch on an old garment, thinking, in my ignorance, that such a procedure might be well advised in certain cases. I presume, however, that the advice is given for the sake of the older garment in order that what remains shall not be destroyed by the too great virility of the new. The evils of patching, in this respect, become well illustrated when we consider the case of their application to atomic structure. A patch in one place is very apt to open up a seam elsewhere; and, while we may make the individual parts of the atomic coat more or less respectable, the thing does not hang together as a whole, as a credit to the atomic tailor.

THE MODERN VIEW OF ATOMIC STRUCTURE

And so within the last ten years physics has undergone a drastic change in its attitude toward what we formerly called a theory of the atom. It was the hope of the last century to see the workings of the atom according to the kind of principles familiar to us in the workings of dynamos, or motors, or springs, or watches, or something which was familiar to us in our every-day life. Alas, we find that if we are to tell the story of some of the most important things that happen in the atom, we cannot reach success in that way without forcing matters to something like the extent that we should have to force the language of Zululand if we were determined to write a treatise on the theory of relativity in it. A modern physicist contents himself by formulating a set of principles according to which atomic behavior may be correlated in its various activities. He leaves it at that and is content. It is not that he has been forced to give up some important ideal born of his former vision of models, but rather that he has come to realize that the comfort to be derived from that vision is largely elusive. The things which in his youth he accepted as obvious and as needing no explanation—the elasticity of springs, the inertia of matter, and the like—examination shows to be by no means obvious, and to call for some elucidation in terms of more fundamental principles of which they are the complex representatives. And so, to the critically minded, there appears a reality in the new artificiality and an artificiality in the old reality. The process of extension of thought into the realm of the atom is not one where the new forms a complication or development of the old, but one in which the old is a rather vague, somewhat incomplete, and somewhat illogical application of the principles of the new.

Were I to attempt to find an analogy illustrating the



Courtesy of The New York Times

This huge apparatus for shattering the atom is being built by Dr. R. J. Van de Graaff for the Massachusetts Institute of Technology. The surface of the sphere at the right is coated with positive static electricity, and that of the other sphere with negative electricity. If the first sphere is overcharged, a bolt of 10,000,000-volt artificial lightning flashes across to the sphere at the left as shown, disintegrating the atoms at a point just within the entrance thereto.

modern theory of the atom, it would not be in terms of models that I should have to seek it, but rather in such terms as the following.

In ancient times, when unaccountable things happened, people attributed them to the gods. If thunderbolts fell, the gods were angry. If all was fair, the gods were pleased. Of course it was necessary to come beforehand to some agreement as to the dispositions of the gods. Now in the modern theory of atomic structure, we may liken the atom to the gods, and a certain quantity which the mathematician calls ψ we may liken to the disposition of the gods. The mathematician formulates certain assumptions about ψ, certain laws which tell us how to calculate it in the normal state of the atom, and in any state of aggravation to which we may subject it. It is as though we had calculated the dispositions of the gods in terms of any set of annoying disturbances. Then we have learned to calculate a quantity called a matrix element, which is analogous to the anger of the gods. There are a variety of these matrix elements associated with any degree of disturbance of the atom. They represent the different kinds of anger of the atom. When the atom is angry it may do one of the various acts which it is capable of doing. It may emit a quantum of energy associated with one kind of light, or a quantum of energy associated with an X-ray, or it may hurl out an electron. If, in general, the atom is angry in a lot of different ways at once, then the chances that it may do the various acts associated with the various kinds of anger are to be regarded as proportional to the intensity of the appropriate kind of anger. It will be observed that there is no certainty that the atom will do any one particular thing. There is merely a chance, a chance which is proportional to the kind of anger associated with that event. The atom is like a cat. You may torment it and it may do nothing, but the chance of getting scratched is proportional to the annoyance of the cat. There is no attempt to make a story of just how the atom operates when it "strikes." Indeed, the physicist has come to see that there is very much less content to that question than might be supposed.

But, you may say, is this not a terribly complicated way of talking about atomic phenomena? No, it is ultimately more simple. In other words, we can get a better correlation between the various actions of the atom by referring them to laws about what we may call the "temperament" of the atom than by seeking an explanation in terms of springs and weights. After all, that is not surprising. Who would attempt to decide what an operatic prima donna, or, for that matter, any other woman, would do under given circumstances by an appeal to the laws of springs, weights, and machinery? The fundamental thing is she is angry, for instance. That is the starting point, and there is no going back of that fact. Everything is accounted for in terms of the anger, but there may be no accounting for the anger.

The modern view of atomic structure at which I have hinted possesses an applicability and meaning over a much wider range of phenomena than was the case with the older theories. It is true that we do not see just how things should go in certain cases, but the underlying general principles seem to be there. The story of the atom's light emission, of the conduction of electricity in metals, of the photoelectric effect, of X-ray phenomena, of electric fields necessary to pull electrons out of metals under different conditions, all of these become told in terms of a common language; and, while the story of the nucleus, and of atom-building processes, has not been completely told, a good beginning has been made.

Quite apart from a complete unifying theory governing all phenomena, however, certain facts stand out on an unassailable basis. The older and the modern theories agree in regarding the atom as consisting of two general parts, a nucleus and a surrounding structure of electrons. The nucleus is the thing which characterizes one atom as different from another. It contains a positive charge which is proportional to the number of the element in a row formed by arranging all of the elements

in such a row in the order of their atomic weights. The nucleus is composed of a system of positive and negative charges, protons and electrons, the excess of the former over the latter determining the net nuclear charge, and characterizing, as I have said, the element. Around this central nuclear structure we have electrons equal in number to the unbalanced protons in the nucleus. To a high degree of approximation the behaviors of the nucleus and of these external electrons are independent of each other. The external electrons have to do with the story of chemistry, of optics, of X-rays, and the like. Only in such phenomena as those of radioactivity, where we think of the nuclei of atoms as breaking up spontaneously, have we, until recent years, come into contact with any observable phenomena following from the structure of the nucleus itself. If to the nucleus of any atom we add protons and electrons in pairs, we produce another atom which may differ drastically from the former as regards its internal nuclear structure, but which carries the same charge and so behaves in the same way in the control of its extra-nuclear electrons. Atoms which differ in this way are called isotopes of each other.

THE CLOSE RELATIONSHIP BETWEEN MASS AND ENERGY

Experiment and theory alike support the view as to the very close relationship between mass and energy. If a positive and negative charge be allowed to fall toward each other from infinity, they acquire kinetic energy. If, when they have come near together, we rob them of most of that kinetic energy, we shall find that the mass of the pair will be less than the sum of the masses of each considered separately. It will be less in every sense in which mass has meaning. We have come to believe that the mass of any system is proportional to the energy which could be obtained by its complete annihilation, and is in fact equal to that energy divided by the square of the velocity of light. Now, although the nuclei of atoms are composed of protons and electrons, we find that the weights of the atoms are not exactly integral multiples of the weight of a proton and an electron. They are slightly less than they should be on this basis. The electrons and protons have lost energy in coming together, and so have lost mass. By accurate determinations of the masses of the isotopes we are able to calculate how much energy would become available in any transmutation of the elements or would be required to produce such transformation. Some of the most significant work in modern physics has been that having to do with these accurate determinations of isotopic masses, and prominent in this field has been the work of Dr. Aston, of Cambridge University, England, and Dr. Bainbridge, of the Bartol Research Foundation. The amount of energy which would become available were artificial atom-building processes brought about is enormous. The hydrogen atom consists of one proton and one electron. A helium atom contains four protons and four electrons, so that the constituents wherewith to make a helium atom are to be found in four hydrogen atoms. However, the helium atom weighs 0.75 per cent less than the four hydrogen atoms, so that one gram of hydrogen in going into helium would lose about 0.0075 gram. This corresponds to such a large energy loss that the production of an ounce of helium from hydrogen would result in the liberation of as much energy as would the combustion of 600 tons of coal. The complete annihilation of the electrons and protons in a drop of water would afford enough energy to provide a hundred horsepower for a year. The possible energy changes involved in any transmutation of the elements are enormously more important than are the changes of the elements themselves. If lead could be changed into gold, the value of the energy released would exceed enormously the value of the gold produced.

POSSIBILITIES OF BRINGING ABOUT TRANSMUTATIONS OF THE ELEMENTS

What, then, are the possibilities of bringing about transmutation of the elements? In the first place, researches in modern astronomy have led us to believe that such transmutation is taking place in the stars and, in particular, in our sun, and that it is responsible for the energy continually poured forth in the form of heat by these bodies. No ordinary cooling process, or indeed any process which does not draw upon a source of energy comparable to that of atomic energy, would be sufficient to keep the sun burning for the enormous length of time that, according to our astronomical data, it has been in existence. We have reason to believe that in the stars very exceptional conditions are encountered. We are forced to admit temperatures of hundreds of millions of degrees—temperatures at which the external atomic electrons would be completely stripped from the atoms, leaving only the bare nuclei. We encounter densities of matter of enormous magnitude so that, in the companion of Sirius, for example, we find substance weighing a ton per cubic inch. It is not out of reason to suppose that in the stars are to be found conditions appropriate for the building of heavy elements out of light ones, with a consequent liberation of energy; and, it has even been suggested that protons and electrons mutually annihilate each other under stellar conditions, and so provide an enormous source of energy.

But the question of interest to mankind is one which concerns how far transmutation may be brought about in the laboratory. Many years ago Lord Rutherford bombarded certain of the lighter elements with alpha particles and was able to break up their nuclei in such a way as to cause them to emit the components of an atom of hydrogen. This constituted a real transmutation of the elements initiated by man, but the agency bringing it about, the alpha particle, had received its energy by an atomic disintegration process outside the control of man. The nucleus is a very tightly bound structure, so that only bullets of extraordinarily high energy are capable of disrupting it. Within the last few years physicists have been developing means of giving to electrons and protons enormous energies such as may be expected to enable them to disrupt atomic nuclei. Prominent among these appliances is the electrostatic generator devised by Dr. Van de Graaff, with which it is hoped to obtain

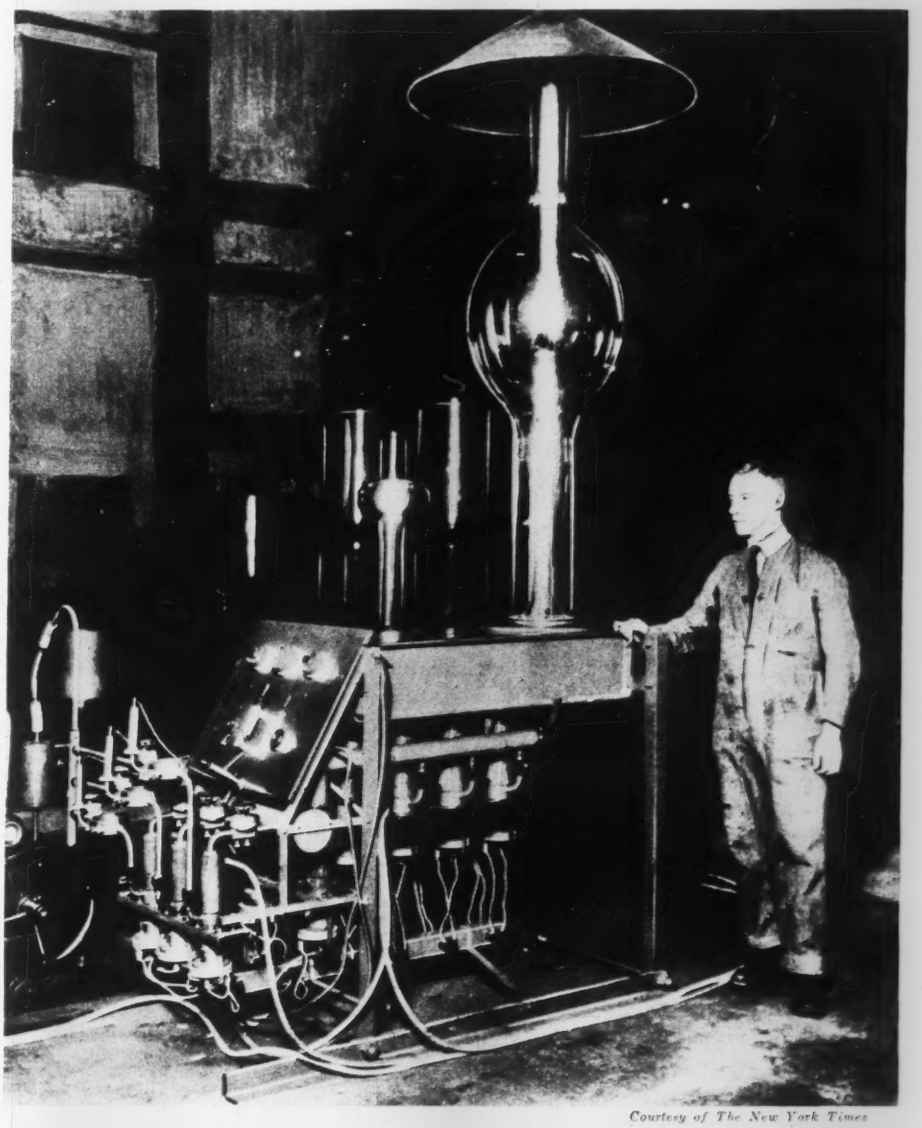
electronic energies corresponding to a fall of potential through more than ten million volts. Then we have apparatus devised by Prof. Ernest Lawrence in which a proton is whirled around in a magnetic field and given a kick each half-revolution, until finally it emerges with a velocity corresponding to a million volts or more. Working in the Cavendish Laboratory at Cambridge, Messrs. Cockcroft and Walton have succeeded in producing real atomic disintegration with protons having energies corresponding to no more than one or two hundred thousand volts. They bombarded lithium atoms with such protons and found that they obtained alpha particles. The mechanism of the process of the production of these alpha particles is as follows: The lithium atom has a weight equivalent to seven protons, approximately. When a beam of protons is shot at the atoms, occasionally one of the protons is caught by an atom, giving that atom a weight equivalent to eight protons. The resulting atom then breaks up into two entities carrying four protons each, and constituting in fact, with their associated electrons, two alpha particles. Here we have a real transmutation of an element brought about by man. A circumstance even more significant than the transmutation itself, however, is the fact that the ejected alpha particles have energies corresponding to eight million volts apiece. In other words, a proton having an energy of only one hundred thousand volts was able to persuade an atom to give up its own energy in an amount corresponding to sixteen million volts. Only a very small fraction of the protons in the initial beam were successful in breaking up lithium atoms, but the efficiency of the process increases with the energy of the protons. At two hundred and fifty thousand volts proton energy, about one in every ten million protons succeeded in producing transmutation.

Then, quite recently, as a result of the work of Bothe and Becker, Curie and Joliot, and of Chadwick, it has been found that by bombarding beryllium with alpha particles of five million volts energy a radiation now believed to be of neutron type was emitted, with an energy corresponding to eight million volts. This gain of energy could only have come from the atom.

COSMIC RAYS AND THE ATTACK ON THE NUCLEUS

The study of cosmic rays has given us a new avenue of attack upon nuclear physics. In these rays we encounter entities carrying energy out of all proportion to the energies of particles which can be produced in the laboratory, or even to those obtainable from radioactive substances. The nature of the cosmic rays is even at the present time in some doubt. Some regard them as electrons entering our atmosphere from space and originating possibly in stellar sun spots. Some regard them as of

(Continued on page 143)



Courtesy of The New York Times

This 600,000-volt apparatus used in the experiments in the Cavendish Laboratory of Cambridge University comprises a conical sparking shield at the top; enclosed glass cylinders mounted on a vacuum box where the atoms were disintegrated and on which the attendant's hand rests; a fine-vacuum pump below the vacuum box; and a mechanical pump at the lower left for use before the fine vacuum pump is set working.

DUST *in* INDUSTRY

Shop Methods and Equipment Effective in Controlling Dust Hazards

By FREDERICK WILLSON, M.D.[1]

JUST at this time employers in dusty trades find themselves in a difficult, if not alarming, position. Not fully warned or informed, until lately, of the special dangers of certain dusts, employers have naturally exercised merely general care in dust prevention.

Under such "general care" some of their workmen—those exposed to silica, and siliceous, dusts—have been found to be suffering (if indeed some have not died) from the physical condition now recognized as "silicosis," either with or without tubercular complication.

At the present day except in some half-dozen states, occupational dust diseases are not included as compensatable under employers' liability laws, hence workmen or their families seeking redress for alleged physical damage must bring such action under the common law. The consequence is that employers in certain kinds of dusty trades are now threatened with much litigation and some monetary loss.

To any one not familiar with the exact situation in industry, it may seem strange that employers did not act years ago to attempt a better control of the silica-dust hazard. This undoubtedly would have been done by most employers if they had been aware of the danger, but unfortunately the subject, although under investigation and fairly well understood in scientific circles, was largely unknown to industry. Dust to employers was merely "dust"—one kind being thought to be as dangerous as another—although, of course, we know today that this is not the case. Most well-intentioned employers may be said to have used "reasonable care" in past years, and this "reasonable care," considering their lack of knowledge, is now their best defense in the damage suits just referred to. However, from now on, with the spread of common, or at least available, knowledge of the peculiar danger of certain dusts, only "special care" will safeguard the interests of employer and workman alike.

PRECAUTIONS NECESSARY WHERE DANGEROUS OR POISONOUS DUSTS ARE PRESENT

Let us now consider what present steps will constitute "special care" where dangerous or poisonous dusts are present: in other words, what shop precautions are now known to be absolutely necessary, based on the knowledge of silicosis just made available to us.

Employers in industries where free silica is present in the atmosphere should constantly be alert and watchful, discounting to the fullest extent every possibility of danger. Employers should not conclude that they have entirely eliminated danger of silicosis, or of any type of pneumonoconiosis, simply because the air is seemingly free from dust. It should be borne in mind that the particles which do the most harm are invisible and that they remain long in suspension in the air. It has been estimated that dust particles one micron in diameter require eight hours to fall six feet in still air, and that even larger particles, 5 microns in diameter, require nearly an hour to fall to the floor from the height of a man. Particles remaining so long in suspension in room atmosphere continue the danger throughout the entire working day, hence the urgency of postponing sweeping and dusting until work for the day has ceased. Often dust is thrown back into the air during these operations. Furthermore, dust of dangerous character may be so extremely fine in grain as never to settle at all but remain in suspension indefinitely.

Assuming, then, that employers in hazardous trades are not only willing but very anxious to protect their workmen, we come to consider the steps by which they can approach the attainment of this end. These steps, undoubtedly, involve not only the expenditure of sufficient money to procure the best possible modern protective equipment (ventilators, exhaust systems, dust collectors, respirators, and the like), but also a readiness to face the expense of subjecting their workmen to thorough physical examination when employment starts, and to reexamination at intervals not exceeding six months during the entire course of employment.

Employers should see that workmen are not exposed to the danger of tubercular infection from one another, that every facility in the way of dressing rooms, lunch rooms, and wash rooms is provided, and that every piece of protective equipment is kept in perfect working order.

Good housekeeping is, after all, one of the major considerations in the protection of workmen where there is dust of a hazardous nature. Dust-exhausting systems are of no use unless they are so applied to the work as to really carry off a large part of the dust and deposit it in receptacles where it cannot again work harm. Preferably the suction should draw the dust downward, away from the face of the operator. Many dust-collecting systems suffer from lack of maintenance, or from not being correctly applied to the operation. In one plant visited last year the author noticed that the flue pipe between the inlet and the exhaust fan had opened at a joint so that air drawn in at the working entrance—if any was drawn in—tended to be thrown

[1] President, Willson Products, Inc., Reading, Pa.

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out again into the room at an elevated point, thus greatly augmenting the original hazard.

Then, too, sandblast cabinets should be kept in perfect working order so that they do not send out into the atmosphere jets of dust from bad joints, leaky doors, or tattered curtains. Frequently the hoods over open sandblasting cabinets are badly designed for protection against fine dust. Helmets used by sandblast operators must be of modern design, supplying to the workman ample pure air, otherwise they are worse than useless.

Workmen having to do with bag filling, loading and unloading of pulverized sand, asbestos, talc, clay, feldspar, and other silicates, as well as those handling lead in bulk, should receive special care, as should also workmen making up batches in glass plants.

DUST-EXHAUSTING SYSTEMS—RESPIRATORS

Naturally, the first type of mechanical protection to come to our minds is that provided by systems of dust exhaustion. These are very effective when the inlets are applied close to the source of dust production, but their utility is less evident when they are considered in connection with suspended dust in large workrooms; in such open spaces ample ceiling ventilation and air cleaners are more helpful. There seems to be difficulty in the way of the removal of fine-dust deposits in room spaces by any mechanical or electrical means other than the direct application of good vacuum cleaning apparatus.

Protection of workmen by means of respirators is also indicated wherever the room air cannot be kept moderately free from dust, and, of course, doubly indicated in operations that are unusually dusty. In all kinds of sandblasting, workmen should be individually protected, without fail. When possible, the form of respirator which provides for the workman an ample supply of pure, fresh air under direct pressure is certainly the best, provided every precaution is taken to see that the air is free from oily vapor and dust. There are, however, some occupations in and around plants where direct-pressure respirators cannot be employed without greatly impeding the necessary activity of workmen, and in such places much care should be taken in the selection of dry-filter respirators to see that these are not only efficient and easy to maintain in good working condition, but also are as comfortable as possible. The use of wet-sponge respirators is a doubtful practice, owing to possible variations in the quality and size of sponge, degree of wetness, cleanliness, and other factors.

Neamith

ELIMINATING DUST IN ROCK DRILLING

(The drill operates through a dust collector consisting of a metal cap connected by a hose line to a suction tank and dust catcher.)

RELUCTANCE OF WORKMEN TO EMPLOY SAFEGUARDS

More often than not employers urge that their workmen are not willing to wear respirators, or that they wear them only occasionally. It must be evident to any one that if this neglect of personal protection is actually practiced, the situation from a protective standpoint could not possibly be much worse. Part-time protection can hardly be considered as protection at all—rather it is only a form of self-deception. If workmen will not wear respirators because of alleged discomfort, an effort must be made to provide them with devices that really can be worn during full-time employment; but full cooperation will probably not be attained without acquainting the worker with the danger to which he will be exposed if totally or partially unprotected.

Getting workmen to wear safety devices requires the same mental attitude on the part of the management that a good salesman must have when he goes out to capture a difficult new account. If the management is not convinced that protective devices must be employed at all times, and if they, in turn, cannot convince their shop superintendents and foremen that such devices are necessary, then they cannot but blame themselves if workmen fail to manifest a good spirit toward self-protection. For psychological as well as for protective reasons, shop superintendents, as well as foremen, when approaching dusty operations should invariably wear their respirators, and even visitors to plants should not be permitted to enter dusty departments without wearing

respirators. In this way workmen can finally be convinced that the management truly believes in full-time protection. For best results every one concerned should be willing to live up to the rules of the shop, without exception. In this work any weakening on the part of the management is fatal.

The most erroneous and expensive policy any employer can adopt is to minimize to his workmen the dangers of free silica dust; no true observance of dust protection can be expected from the workman unless he is fully acquainted with the dangers of his occupation.

It cannot be assumed that workmen in our American factories are so unintelligent as to wish to ignore dangers about which they have been fully informed. Rather they, like the rest of us, are apt to scoff at occasional warnings, preferring to doubt that danger exists. It is essential, then, that the management should know the truth first of all. Supervisors should be told the whole story, and workmen severally and individually, in season and out of season, week in and week cut, should be educated, warned, and even cajoled into full observance of the rules. Anything short of this will never bring about a decrease in silicosis where free silica is handled. Unless this end is attained the burden of liability expense, whether determined by civil suit or by workmen's compensation laws, will grow progressively heavier as statistics accumulate.

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ROCK DRILL MOUNTED ON TRIPOD AND EQUIPPED WITH DEVICE FOR THE ELIMINATION OF SILICA DUST

(The bottles shown on the tripod measure the amount of silica which will be inhaled by the drill operator.)

Where this has not already been done it would be wise, as an additional precaution, to organize shop committees in dusty plants. These committees, selected from management, supervision, and common labor, should make periodic inspections of their respective plants and draw up recommendations for improvement in equipment and shop maintenance. Recommendations made by shop committees so constituted are generally more convincing to workmen than orders issued directly from headquarters, and considering the situation as to liability, no step, however radical, is to be overlooked or neglected. Liability cannot be lessened by having workmen sign waivers, or by any other means than protection and prevention.

PROBLEM OF LEGISLATION IN OCCUPATIONAL DISEASES

At the present time there is a need for the inclusion of pneumonoconiosis (a general term covering fibrotic lung conditions due to mineral dust) in the workmen's compensation laws of all states in which it does not now appear or is not clearly covered by implication. It is certain that a number of evils in legal practice which now exist would be eliminated by taking damage suits for such occupational diseases out of the civil courts. At best, however, the problem of legislation in occupational diseases is a difficult one, as many states now considering the subject fully realize. There always remains the difficulty of determining the degree of injury and the exact final outcome. Thus opinions cannot be fairly framed except after the most careful and intelligent study of clinical symptoms and X-ray records.

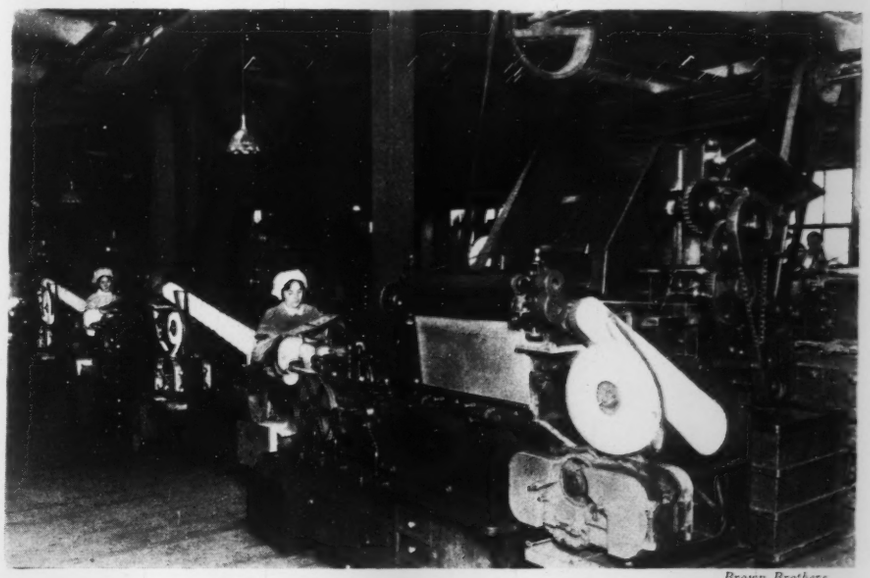
The truth, then, is forced upon us that, after all, the best way to meet the situation as it is unfolding is to start now to take every possible step in the direction of prevention. As long as new cases of silicosis continue to appear, employers will have to foot the bill, often rather unfairly through civil-court trial, or probably in a fairer way under the workmen's compensation laws; but in any case the obligation remains. Insurance companies, if they carry silicosis risks for employers, will demand a rate which will meet their losses, so in the long run there is but one answer, and that one is the complete education of the employer and his workmen—combined with unremitting efforts toward prevention.

When management and workmen pool their interests in behalf of safety, then certainly safety will finally be won. Research lies with the scientist, but the intelligent application of the knowledge thus obtained, as it applies to occupational diseases, is a moral responsibility of industry.

The Social Effects of MASS PRODUCTION

By DEXTER S. KIMBALL[1]

IN THE center of the theater district on Broadway, New York City, behind large plate-glass windows, there stood a short time since a modern cigarette-making plant. One machine fed constantly with pulverized tobacco leaf and wrapping paper ejects continuously a cigarette bar which is cut into standard lengths as it issues from the machine at the rate of 500 cigarettes a minute. A neighboring machine takes the cigarettes and automatically places them in packages, closes the latter, and delivers the finished marketable product. The degree of skill required to operate the machine is small, though of course some one must fully understand the mechanism and be competent to make adjustments. At the other extreme of size, consider the automatic factory of the A. O. Smith Company, of Milwaukee. This great machine literally takes in steel plates at one end and ejects finished automobile frames at the other at the rate of 8000 daily. The machine, for such it virtually is, cost $10,000,000 and requires only 200 men to operate it. Probably 5000 men would be required to produce the same result with ordinary processes. Here again of course there must be a certain number of skilled engineers who can adjust the machine, but the labor cost of actual operation is comparatively insignificant.



Brown Brothers

A BATTERY OF CIGARETTE-MAKING MACHINES

A survey of any progressive industry will reveal similar developments and constant progress toward the mechanization of its processes. Everywhere one finds the handicraftsman displaced by the machine and the semi-skilled operators, backed by the most lavish use of power the world has ever witnessed. In many instances the product is equal to or better than the work of the artizan, and in all cases the volume of product per worker is vastly greater than can be achieved by handicraft. Of course, there is nothing new *in principle* in these developments, which began with the first stone axe and culminated in the Industrial Revolution. Until that event the tool had always been an adjunct to the skill of the worker; but the developments of the Industrial Revolution made the worker an adjunct to the machine.

THE RAPID PACE OF MECHANIZATION

Since 1900 the mechanization of industry has proceeded at a rapid and apparently at an accelerated pace. As long as industry was prosperous and displaced workers, in some measure, could find work elsewhere, little attention was given to this tendency, though thoughtful writers have from time to time called attention to the problem. But the present depression has aroused more interest in the basic reasons for unemployment than any other in modern times, and for the first time "technological unemployment," as this displacement of labor is called, appears as a vital issue and as a possible factor, in a large way, in the general problem of unemployment.

The most natural reaction on first observing productive processes such as have been described is one of concern for the skilled workers who may have been displaced by the new invention and a consequent belief that such advanced methods cannot be conducive to the welfare of the workers. If, however, the observer should voice such fears probably he would be reminded of the great economic gains made by this country since modern manufacturing methods came into use, and his attention would be

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[1] Dean, College of Engineering, Cornell University, Ithaca, N. Y. Past-President A.S.M.E.

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directed to the high scale of living that the workers in this country enjoy, the inference being that modern methods of production cannot in the long run be anything but helpful for all. While much can be said in support of both of these somewhat antipodal assertions, neither of them reveals the trials and tribulations through which many men have passed in building up our present level of existence, they throw no light upon the complex forces operating in the industrial field, nor do they even in a remote manner advise us as to whether the net trend is for good or evil.

Whenever an advanced process, such as those referred to in the foregoing, is set in motion, several economic changes at once become operative. The first is an increase in the capital investment and a further separation of the worker from the ownership of the tools of industry. This tendency is not connected directly with the present discussion, except that it has progressively closed certain avenues of escape open formerly to the worker under simpler industrial conditions. As industrial equipment has grown more complex and more expensive, the worker's industrial independence has decreased until today he is no longer an economic self-sufficient unit, but is dependent largely upon capitalistic management for an opportunity to earn his daily bread. Consequently the need of protective measures in his behalf increases daily.

DISPLACEMENT OF LABOR BY MACHINERY

The greatest and most immediate menace to the worker because of industrial progress is this displacement in favor of more highly developed machines in the hands of less skilled workers, or "degradation of labor" as it has been called. In the early days of the Industrial Revolution in England the ruthless application of improved methods in the textile industries and the displacement of handicraft workers by machinery operated by children of tender years, forms one of the darkest pictures in modern industrial history. Such direful conditions never prevailed in this country, even in the earliest days. Industry itself was in the making, the frontier was always accessible, and a change from one calling to another not so difficult as at present. Even during the rapid expansion and development of industry in the latter half of the last century, technological unemployment was never a serious issue though it had begun to raise its head. This is not to deny, of course, that at times and places much distress has occurred because of such displacement. Industrial progress is necessarily accompanied by change, and apparently such change is necessarily accompanied by suffering on the part of some. Progress, change, and distress for some persons appear to be concomitant. The U. S. Census Report of 1900 mentions this tendency specifically as a menace to the wage earner, and predicts a doleful future for the wage-earning class in the following words: "A factor that has a real tendency to lower the actual earnings of the wage earner in many industries is the displacement of the skilled operator by machinery which permits the substitution of a comparatively unskilled machine hand. This tendency is noticeable in many lines of industry. Its effects are twofold: to reduce the number of employees producing the same or an increased quantity of product, and hence to lower the total wages of the group; and to reduce the average rate of wages because of the lower degree of skill required. The effect of the introduction and improvement of machinery upon the condition of the skilled artizan is an economic question of the greatest importance." Here is analysis and prophecy, the accuracy of which will be discussed subsequently, after an examination of some other phases of the problem.

If this displacement of labor, as described in the foregoing, were the only effect of modern productive methods, we should have found ourselves long ago in great difficulties. But improved machinery, while frequently displacing labor of a certain degree of skill, provides employment for workers of a lesser degree of skill, and thereby "extends" the field of industry to workers who otherwise could take no part in modern manufacturing. Hence in the older callings that have been mechanized, shoes are no longer made by shoemakers, watches by watchmakers, or knives, forks, and spoons by skilled cutlers and silversmiths, but by semi-skilled workers operating highly developed machines. More important still, these new methods and processes have made possible the building up of new enterprises of vast proportions such as the sewing-machine, the automobile, telephone, radio, refrigeration, and other new industries, and which but for modern methods must have remained small in size, with their products classed as luxuries. And these new mechanized industries in turn have given rise to supporting industries of great importance. Thus it is estimated that the automotive industry when busy gives direct employment to 800,000 workers and indirectly to 4,000,000 workers who supply equipment, raw materials, accessory parts, gasoline, etc.

The plants of the Western Electric Company, which is the manufacturing arm of the American Telephone and Telegraph Company, have a normal capacity of over 50,000 workmen, and the supporting industries must employ many thousands of workers. One wonders what this army of men would be doing if these new developments had not appeared.

NET RESULT OF MODERN METHODS A GREATLY INCREASED OUTPUT AT LOWER PRICES

The history of the development of these new factors in our existence should be noted, for it gives a clue to the character of the inventions which may be needed to hold the pace that has been set. The story of one is the story of all. First, there appears the period of invention, and incredulity on the part of the public. It is only a few years ago that the electric motor was looked upon as an interesting toy, and the same was true of the telephone. A very few years ago the drivers of "horseless carriages" were viewed with mild amusement. Then comes the period when it is a luxury to possess one of the new devices. In the year 1880, for instance, it cost as high as $280 to have a private telephone. Finally when the new device has proved its usefulness, mass production reduces the cost and it becomes an economic necessity, the number in use depending sometimes, as in the case of the watch, almost solely upon the population. The sewing machine, the telephone, the automobile, and other modern products have all justified their existence economically. It should also be noted that the driving power back of these modern methods is increased production and decreased costs. And it is a peculiar characteristic of these methods that as the quantity to be manufactured is increased, the unit costs can be decreased, which stimulates consumption, and this in turn reacts upon production, thus creating an ever widening cycle of increasing production and decreasing costs until some limiting factor checks the movement. The results of this cycle are too well known to merit discussion, but it may be noted that in all probability the greatest value ever offered the public for every hour of labor expended is to be found in some of the moderate-priced automobiles. How cheaply they may eventually be produced, time only will tell. The net result of modern methods, therefore, has been a vast increase in the quantity of manufactured goods and a remarkable decrease in their cost. It should be remembered that these methods have also been reflected in the basic industry, agriculture, and it would appear that the problem of production is fairly well solved since at this moment we are producing more goods and more food than we can conveniently use, or rather more than we can intelligently distribute.

In résumé, therefore, as industry advances, some classes of workers are displaced, while at the same time other workers of lower degree of skill are given employment in callings hitherto closed to them. The displaced workers may find employment at the same economic level elsewhere, or they may be compelled to drop to the level of the new semi-skilled group. If the displaced workers are skilled in the machine-building trades, they are usually absorbed by these callings, and the movement in general has been of advantage to the so-called "mechanic arts" group through the great development of the machine-construction industries. Other classes of workers have not been so fortunate, for it should be remembered that it is very difficult for a mature man of limited education to change his calling, to say nothing of the restrictions now imposed by trade unionism upon such changes. The statement so often made that displaced workers "find work elsewhere" is not in every case true, and if they do so it may be at an economic sacrifice. In time, of course, the displaced workers pass out of the picture so far as their old vocation is concerned, and the calling appears in a greatly modified form.

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For the new groups that have been recruited, the conditions are usually the reverse. Given a small amount of training they can be made more highly productive than formerly, they can render a greater service to society, and their remuneration in general is increased. That is, they may be, and generally are, elevated economically, and as a natural result, socially. The absorption of immigrant people and their descendants by the industries of New England and their economic and social elevation is too well known to need discussion, and the process still continues, not only there but in every manufacturing center of this country.

Until quite recently our industrial progress was viewed with considerable satisfaction. Our per capita wealth has risen from $383 in 1850 to about $3500 at the present time. Our national wealth has reached the unprecedented total of about $400,000,000,000, and our national income approximates $90,000,000,000, a most remarkable amount. Our scale of living has exceeded anything in history, and despite the present depression, other

nations, notably Germany and Russia, are eagerly studying our methods and adopting those that may help them to emulate our success. It appeared to many of us that we had really entered a new era and that we had in some measure solved the problem of living through high wages and a constant increase in the manufacturing cycle that has been described. The depression, therefore, came as a very painful reaction to many.

Economists in times past have usually looked for the causes of depressions in the law of supply and demand, a change in the supply of gold, or in some disturbance in international trade, all of which would be adjusted with time. But now for the first time a new and sharp question is raised concerning our manufacturing methods and equipment, and the fear is expressed that our industrial equipment is so efficient that permanent overproduction, for the markets available, has occurred and that consequently technological unemployment has become a permanent factor unless remedial efforts are put in force. Other critics contend that our methods of distributing the products and profits of industry are hopelessly antiquated, and that overproduction cannot occur as long as there is poverty, want, and ignorance. It is indeed a paradox to see storerooms filled with raw material, shoe factories equipped with the most efficient machinery man has ever produced, and workmen, anxious and willing to work, walking the streets almost without shoes for themselves or their families. It is not the province of this article to discuss the last contention, but it must be admitted that our present methods of distribution are hopelessly behind our powers of production in scientific background and direction. And without doubt we shall not achieve any marked relief from some of our industrial troubles until the same methods of analysis are applied to distribution, including tariff making, that have produced our magnificent machinery of production.

PERMANENT TECHNOLOGICAL UNEMPLOYMENT UNLIKELY

Many economists believe that permanent technological unemployment is unlikely or even impossible. Briefly, they argue that, as has been stated, technological progress increases the quantity and reduces the cost of product. This in turn creates a greater demand and hence enlarges the opportunities for labor. Or, if the demand is inelastic, even at reduced costs, the savings, either to the consumer or the producer, are eventually invested through banks in the production of other products, and thus the field of industry is indirectly expanded. Unfortunately, we have little quantitative knowledge concerning these complex relations. There are some facts concerning some individual industries, however, that are illuminating.

Brown Brothers

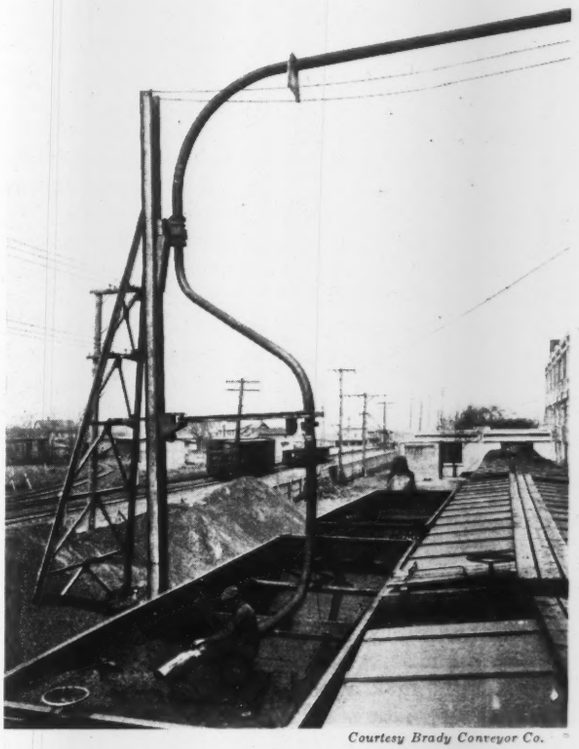
The Census of 1900 lists the number of workers in the shoemaking industry, both handicraft and factory, as 153,600, and gives their earnings as $63,304,344, or about $415 per person. This industry has been very fully mechanized, yet in 1914 the number employed was 191,555 with average earnings of about $522 per person. In 1925 there were 206,992 workers in the industry with total earnings of $225,787,981, or about $1090 per person. The purchasing power of the dollar of 1925 was about 66 per cent of that of 1914 and 53 per cent of that of 1900, but even with these allowances there has been a gain in real wages since 1900. Furthermore, in 1900 there were 4849 children under 16 years of age employed in the industry with yearly earnings of about $177 per year per child. No such conditions are tolerated today in progressive states.

Again, in the printing industry, which also has been highly mechanized, the Census of 1900 gives the number of workers as 162,992 with yearly earnings of $84,249,963 or about $517 per person. The census of 1925 lists 251,276 persons as employed in this calling with total annual earnings of $438,832,974 or about $1746 per person. Here again, allowing for the difference in the value of the dollar, there has been a decided gain in earnings. Furthermore, such statistics do not take into account the increased employment due to the production of machinery for these industries. In 1925 the value of the printing machinery produced in the United States was $69,216,683 and the corresponding value of shoemaking machinery was $11,769,137, and each of these machine industries in turn has many ramifications, the money value of which would be difficult to compute. No doubt an analysis of other industries over this period of rapid mechanization would show similar results, and it would appear that so far as some individual callings are concerned, the recorded experience does not bear out in any way the gloomy predictions of the editor of the Census of 1900 quoted in a preceding paragraph. And it is fair to assume that under present circumstances any calling that is transformed by mechaniza-

tion will stabilize "in the long run," as economists say, on a higher level, so far as those workers who survive the change are concerned. We need not be troubled apparently as to the *final* results of such metamorphoses. It is the *immediate* results of such changes that are now engaging the attention of thoughtful men.

DIFFICULTIES ENCOUNTERED BY DISPLACED WORKERS

It is usually assumed by ardent advocates of industrial progress that the workers who are displaced by reason of advanced technological methods, whether mechanical or administrative, will find work elsewhere. This is not so easy to do. In former days when industry was simpler, less specialized, and less highly organized, such a transfer was not so difficult without great loss of time or economic standing: but conditions are vastly changed. The displaced worker is, in general, debarred from engaging in his wonted calling on his own responsibility, both for lack of funds and of administrative experience. It is this lack, indeed, that makes cooperative production so difficult, if not impossible, under modern conditions. Again, the displaced worker cannot, in general, engage in some other calling, at the same economic level, since his knowledge, skill, and experience are not transmutable. If he does find employment in some other calling it is usually at a lower salary—that is, he suffers degradation of labor, so called. The few statistical studies that have been made of this problem indicate clearly that many displaced workers find employment elsewhere only after a considerable period of idleness and often at a lower wage scale. These difficulties are of course greatly increased where the decline in employment is such as to require the worker, and perhaps his family, to migrate to some distant point, a procedure that he faces with greatest reluctance. The most startling index of these new and changed conditions is the growing group of men over forty years of age that are finding it very difficult to get a foothold in industry once they are displaced for any cause. In this sense it may be that permanent technological unemployment already exists to a certain extent. It is therefore the immediate and not the ultimate results of technological progress that are of greatest concern, and it is an open question as to how far we should permit the good of the majority to be advanced at the cost of suffering and poverty on the part of the minority. We are sadly lacking in accurate data as to the quantitative results of modern methods as affecting permanent unemployment. Perhaps nothing but a careful study of these phenomena or a pragmatic return to normal production can reveal to us with surety just what the true trends are, but in the meantime there are indications enough to put us on our guard as industry becomes increasingly scientific in its background and practices.



Courtesy Brady Conveyor Co.

WHAT THE FUTURE MAY HOLD IN STORE

If an understanding of past progress and present conditions be important, some estimate of what the future may hold is even more so. The last thirty years have witnessed an unprecedented improvement in the science and art of production. Not only has this reshaped many of the old callings, but in some cases new and unheard-of industries based upon scientific processes have placed products on the market that have threatened or even obliterated old industries. In addition the entire philosophy of industrial management has been rebuilt and made much more efficient. In its effect modern management is analogous to improved mechanical methods in that it aims to produce more per worker and hence tends to technological unemployment. There has also been a vastly greater use of power, particularly in heavy construction. Dean W. B. Donham, of the Harvard Graduate School of Business Administration, in his excellent and thought-provoking book "Business Adrift," voices the opinion that "Technological progress in the direction of better processes and methods will continue and accelerate during the generation ahead of us." He makes a similar prediction concerning the progress of efficient management. This may or may not be a true prediction, but if it be true, there are certain features of our economic life that must be studied carefully if our present system is to endure, and if we are to keep up the present level of existence and escape extreme technological unemployment.

OUR HOME MARKETS MUST BE DEVELOPED EXTENSIVELY

First, our home markets must be developed extensively. Foreign trade must of course be cultivated as heretofore, for the United States is far from being self-sufficient in the materials needed in modern industry, and it would appear that progressive nations are increasingly interdependent. But the field of foreign trade promises to be a very crowded place in the near

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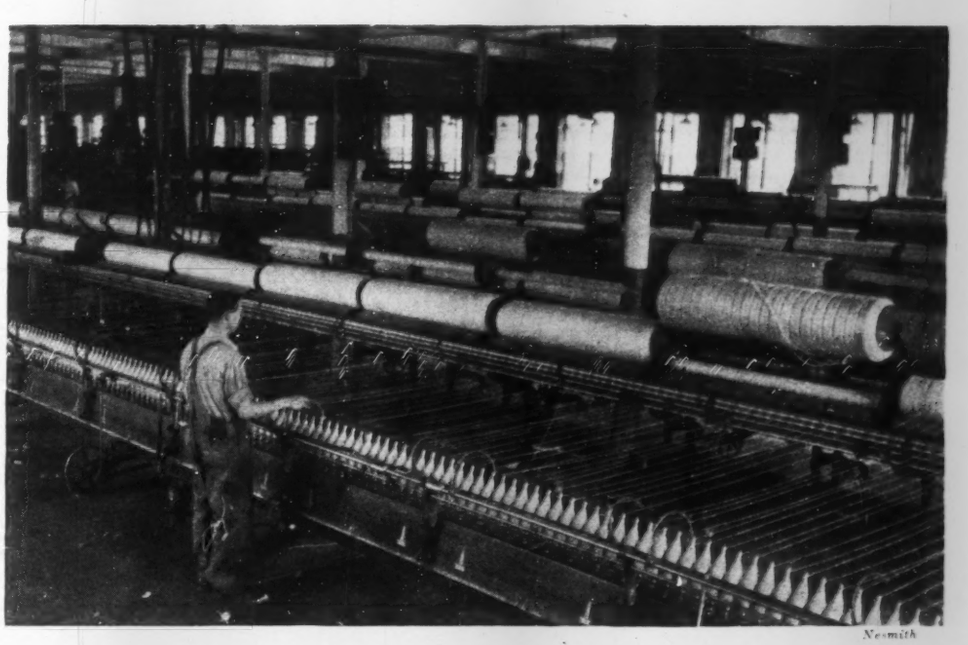
The illustrations on these facing pages provide an extraordinary contrast. Home handicraft has all but disappeared from the Western world, and with it has gone the social structure that supported it.

future, and one in which our high tariff will not be a welcome passport. This means also the full evaluation of such economic theories as high wages and consequent high purchasing power. Our own people now purchase 90 per cent of our products, it is said. Can this ratio be maintained if new methods greatly increase production? New inventions of economic value must be found which, like the automobile, the radio, etc., will absorb the surplus labor and the increase in population. No such inventions are at present on the horizon, but no one knows what the day may bring forth. Industry individually and collectively must plan a program years in advance, and thus endeavor to reduce the periods of feverish activity and corresponding periods of depression. Much thought is even now being given to this problem by forward-looking industrialists and economists in the hope that the business cycle can be controlled. Manufacturing must be freed from the incubus of speculation. Its inherent troubles are great enough without being thrown out of balance periodically by spasms in the stock market. It is inevitable, I believe, that we shall come to a shorter working week. There is nothing new or startling in this idea. Not many years ago the working day in most factories was twelve hours long for six days in the week, or 72 hours for the week. This working period has fallen steadily to approximately 44 hours a week or eight working hours a day. How much shorter the working week may be, time and technical developments alone will determine. And, lastly, management must provide a greater degree of security for the worker against unemployment and indigence in old age, the two calamities most dreaded by the worker. In such a program the effect of new technological processes in occasioning unemployment must be studied in advance of their application. It may well be that we shall see legislation making it obligatory upon the part of ownership to provide some means of escape for displaced workers, though a happier solution would be a humanitarian interest in this problem on the part of the employing class that will minimize this difficulty by allowing longer periods of readjustment and such provision for the transfer of displaced workers as may be possible. Unless some such program as this can be put into effect, an acceleration of our industrial machinery will make life unbearable for a large part of our population.

REASONS FOR BELIEVING THAT THE RATE OF PROGRESS WILL SLOW UP

Personally, I am not convinced that the rate of progress during the next thirty years will be as rapid as during the last thirty. Scientific progress we shall surely see, and this is sure to be reflected in our industrial methods. But there are also reasons for believing that retarding factors are already at work. The most important of these is the old law of diminishing returns that so far has never failed to put in an appearance where economic progress has been active. Only a few of the more easily recognized indications of the working of this principle can be given here.

Consider first the transmission of intelligence by the telegraph and the telephone, which probably have accelerated the pace of modern industry as much as or more than any other factors. It is not conceivable that this quickening effect can be greatly increased. The solution of this problem is practically perfected. Since 1880 the time required to cross the continent by rail has been reduced from eight days to less than four. It is not conceivable that the next fifty years will witness anything like a proportionate reduction in rail time, and flying is still to be fully developed. Again, in 1880 steamships were crossing the Atlantic in about eight days. The new giant liners now under construction are expected to make the passage in four days. Again



Mass production by means of power and machinery has introduced a new and rapidly changing social order. In adjusting themselves to new conditions, men have greatly advanced their standard of living.

it is not conceivable that this time will be reduced to two days in the next fifty years. The new methods of industrial management have accelerated industry, and much more can be done in that field, but their limitations have already been evaluated by thoughtful observers. It is a well-known fact that in all engineering it is becoming progressively difficult to increase the efficiency of operation of power plants and machinery in general.

ECONOMIC LIMITATIONS TO GROWTH IN SIZE OF MANUFACTURING ENTERPRISES

Lastly, and most important of all, there are good reasons for believing that there are economic limitations to the growth in the size of manufacturing enterprises, and consequently to the efficiency of mass production itself. Indeed, if the facts were known, it probably would be found that many modern industrial enterprises have already passed the point of greatest efficiency and greatest economic returns. The value of the industrial product per worker in this country in 1900 was about $1600, while in 1919 (the last census in which such data are available) this ratio had risen to $7500. Making due allowance for the changed value of the dollar, this is a great gain in production per worker. But *the ratio of the value of products to the capital invested has decreased* steadily for a number of years. In 1850 this ratio was close to 2, but it fell progressively until in 1919 it was only 1.39. This would appear to indicate that even if the number of workers is materially reduced in favor of more refined machinery, the cost of production will eventually rise with increased complexity of mechanisms. This is already foreshadowed in some industries where the fully automatic machine as yet is not so economical as the semi-automatic operated by a skilled worker. Barring some new and eruptive change like the Industrial Revolution, there is little likelihood of startling changes in the immediate future.

NEW METHODS HERE TO STAY

Finally, whether industrial progress be slow or rapid, these new methods are here to stay and their deeper significance should not be forgotten. Through them there is held out a hope that as we have achieved political and religious freedom, so we may also achieve economic freedom, freedom from physical drudgery, and an opportunity for all men to live like men and not like beasts of the field as the majority of our ancestors have done. But this will be no easy task, for it involves many changes in our ideas of economics and government. It involves the discarding of some economic ideas and taboos of Adam Smith and others who viewed industry as handicraft and the worker as a self-sufficient economic unit. And it also involves a realization on the part of ownership that it can no longer absolve itself from the responsibility of either controlling the business cycle or making the effort to provide continuous dividends to industry as it now does to insure continuous returns to capital. We cannot continue with the present uncertain methods faced with even moderate technological progress.

Make no mistake in this matter. If we shall achieve a semblance of economic freedom for all men, a high standard of life, security, and delight in work, and leisure, it will be through much trouble and opposition such as men have always encountered in winning political and religious freedom. There is an opportunity to attain this economic freedom in the United States by peaceful means, and this problem offers a challenge to business men, economists, and engineers such as no similar group has ever had. Will they have the vision, courage, and intelligent statesmanship to accept this challenge?

Educational Preparation for Creative TECHNICAL ENGINEERING LEADERSHIP

By R. E. DOHERTY[1]

If we are to meet our clear responsibility to train leaders who will be able to cope with the heavy, complex problems of the future, we must modify our educational objective. It is now one-sided; properly it should be bilateral. The acquisition of knowledge and of proficiency in manipulative techniques is only one half; the other is the art of utilization of knowledge. We must add this vital half to the objective. Instead of paralyzing thought by cluttering the mind with inert knowledge which will never be used, and burying at the bottom of the heap valuable fundamental knowledge, let us, under the pressure of our crowded program, courageously and carefully eliminate debris, and provide in its place the vitalizing and unifying force of independent, constructive thought. We are supplying mental food without vitamins; let us plan to provide these also.

IN DRAWING before you now the old thought which every novice in educational work must sooner or later propose, and which is also urged by those practicing engineers who mean to be educationally helpful, I fully realize that my job is a precarious one; for there is not a teacher among you who does not try to develop scientific thinking in the student, as far as this seems possible in view of the limited allotment of time and of the subject-matter to be covered. However, I am moved to make an appeal to you, because from personal observation of many engineering graduates in practice I am convinced that scientific habits of thought are not developed at college to the extent they should be.

There is a crying need for men with such habits of thought. They are needed to solve the internal problems of technical engineering and engineering management in industry. Moreover, if the difficult and deep-seated external problems growing out of the relation between technological progress on the one hand and a balanced, healthy social structure on the other are to be solved, it will be because more constructive thinkers are available than there are now. Indeed, in a still wider sweep, if Western civilization itself is not to go the way of all its predecessors, as Oswald Spengler says it must, it will be likewise because there are enough sound and active thinkers in all professions to give some direction to destiny, by making effective use of the great store of scientific knowledge which this civilization possesses, but which its predecessors did not. Scientific knowledge provides foresight only when it is properly used, and such use requires constructive thought.

The engineering profession has, in all of these problems, a peculiar responsibility. It has responsibility naturally to carry ahead technological progress; to pull into efficient gear the present disjointed machinery of industry and business, which condition its technology has largely created; and it has responsibility to help keep it in gear as new technological advances tend to throw it out. All professions, of course, have heavy responsibility, but engineering especially.

As a final introductory word, it seems proper that I should outline the point of view from which my analysis has been made, so that you can accordingly appraise the conclusions. This viewpoint, I must confess, is not altogether competent. It is competent, I believe, as regards a fair estimate of the product of engineering education, an evaluation of existing educational objectives, and, at least to a moderate extent, the critical examination of methods and curricula in graduate work. Contrariwise, it is less competent by reason of insufficient first-hand experience as regards *method* in undergraduate work. As a basis for this point of view, it has been my privilege in a large manufacturing industry to study, at close range and over a period of years, both the educational attainments and the professional performance of large numbers of engineering graduates and postgraduates, representing practically every engineering college in the country. In such an industry the range of engineering activity covers practically the whole gamut—from the technical clerk to the creative genius; from the isolated specialist to the executive. In teaching and in directing with a free hand the educational activities of these graduates, I had opportunity to learn something regarding method of handling graduate work. However, I have had as yet practically no first-hand experience in undergraduate teaching. In this my knowledge rests on a study of the engineering curricula of American colleges, S.P.E.E. reports, and on discussion with teachers of science and of engineering. Whether all of this is a competent basis for such a conclusive judgment as I shall reach, you will have to decide.

A PROGRAM FOR DEVELOPING CREATIVE LEADERS

In turning to my topic itself, may I emphasize the general subject of the meeting—Educational Preparation for Creative Technical Leadership. My thoughts relate, not to the training of engineering technicians, but to the development of creative leaders, and therefore to students who possess the natural ability to rise to such leadership.

[1] Dean, Yale School of Engineering, Yale University, New Haven, Conn.

Presented at a meeting of the New England Section of the Society for the Promotion of Engineering Education, Orono, Maine, October 8, 1932.

I recognize the practical difficulties which may be encountered in accomplishing that object. The means of selecting such students are only partially efficacious, and a program which is most appropriate for the one type of student is utterly inappropriate for the other. But I do not suggest that we are considering an easy problem. It *is* difficult; but it is worth the effort. To do a good job in the early development of the relatively small group of naturally capable students—to lay a sound, scientific foundation fully appropriate to professional, creative leadership, and to develop mental power—is, in my opinion, the greatest responsibility of our colleges and universities.

So my proposal is to provide a program for such students which shall be designed for the specific purpose of developing engineering thinkers—men with a scientific and scholarly attitude of mind, and with the ability to make the most of experience. Better that we set our course in higher education definitely in this direction, absorbing some of its graduates in the middle levels of professional activity, than to set the course toward the middle, as it now seems to be, and trust to chance that creative minds will somehow emerge.

Now of course we must have engineering technicians too. An adequate number of technically trained men to "carry on" are just as essential to technological progress as is the creative group. Indeed, the two groups are complementary. A rational plan for providing this other and much larger group of engineering technicians would involve two sources. One is the technical institute, which has been the subject of a special report of the S.P.E.E. by Dr. Wickenden. In addition, there would always be a large fraction of college graduates of those courses designed especially for the development of engineering leaders, who were not quite constituted for the intended purpose, but who could nevertheless fill in the gap between the upper and lower levels of engineering activity referred to.

EDUCATIONAL SITUATION OF THE LAST DECADE

Consider the educational situation of the last decade, and the reasons for it. I refer to the relation which college training in engineering has borne to the requirements in the field, and thus to the performance of the graduates.

The colleges have graduated too many engineering technicians and too few creative thinkers. For normal business conditions there may be too few technically trained men, including all kinds, as the National Industrial Conference Board and almost every one urged before 1929; or, on the contrary, there may be too many, as it now appears to those who believe we are entering a new era in which the demand for such trained men will be much less. I do not know. But I am sure of one thing, and that is that there are not enough thinkers. The ratio of thinkers to technicians is too low, and has been so during the decade. Any one who has examined hundreds of graduates in an endeavor to ferret out the thinkers will appreciate the full significance of this statement. They are hard to find, not only because such a small portion of them are naturally constituted for any great degree of independent, effective thinking, but also because those few who are have had so little practice at it under their own steam that their reasoning power is not easily recognizable. Through long disuse it has tended to remain puerile. I am convinced that many young men with minds potentially capable of independent thinking never have this dormant power in them awakened and developed during their whole lives. The spark smolders under a great tonnage of engineering facts, formulas, and figures; it is not uncovered so that it can ignite the fire of searching thought, and thus light up their minds. Only in those few students in whom that spark is by nature a dominating force, and who therefore instantly respond to the slight encouragement which it is possible to give them in the present heavy college program—only in such students does it burn its way through to the surface and grow. In the others, such a mass of inert knowledge gradually induces paralysis of thought. Consequently, of the thousands whom the engineering colleges have graduated, too small a percentage have been real thinkers.

An interesting phenomenon for our study here is the usual engineering graduate when he faces for the first time in practice a real engineering problem. In learning from others how to do a routine job—for example, the calculation of stresses or densities in design—he is usually very apt; in college he became proficient in making such slide-rule calculations from formulas. But when a problem confronts him for which there is no formula, what happens? A river to swim, and he can't swim. His muscles may be strong, but they are undisciplined and unpracticed at swimming. He paddles around in shallow water looking for shoals, which are not there, to hold him up in crossing. As the time approaches when he is expected to be on the other side, he is seized with emotions which are dark and despairing. Finally he sees a way; he goes across on somebody's back. It works out all right this time, he thinks; the ride is interesting and also similar to many he experienced at college, so he now knows how to get across the next time. Thus he comes to the habit of remaining in shallow water unless he can find a good, broad back to ride on where it is deep.

If my interpretation of the last decade is at all accurate, there is occasion for us to go still deeper into our educational problem than we have gone. I need not emphasize to this assembly the progress which has been made in that period, due largely to efforts of the S.P.E.E. The results are salutary indeed. A trend from specialized to fundamental subjects, toward the segregation of students according to ability, toward a unified program, a keener interest of teachers inspired by the summer schools, etc.—all of these are worthy, fundamental results. And from them, real improvement is under way in commensurate respects. The problem to which I have referred, however, is only slightly touched by them. Subject-matter cannot solve it; teachers' interest, under existing schedules, cannot solve it; and even the segregation of students including an honors group—which is a most promising step—cannot solve it merely by a broader and more rapid pace over the same ground in the same direction. The problem is not to be solved by such modifications alone; something more is necessary.

QUESTION LARGELY ONE OF BASIC EDUCATIONAL OBJECTIVE

It is largely a question of sailing direction—of basic educational objective. As nearly as I can understand the prevailing idea in this country regarding the purpose of all education, from kindergarten through college, it is that students should temporarily gorge their memories with facts and figures and rules about the largest possible number of things, all with the idea that after graduation much of it will gradually drain off, reducing the plethora and leaving a residue which may prove useful in life. There may be also the idea that the very process of gorging and elimination is somehow constitutionally beneficial—that it inures the memory structure to heavy burden, like a banquet does the visceral structure. This memory gorging, which in most other college courses is burden enough, is in the engineering courses of American colleges both increased and supplemented by long and exacting tabulations of data, the preparation of numerous routine reports, and the

like until the students' time is thus completely consumed. Emphasis is upon memory and techniques of manipulation instead of upon disciplined, independent thinking. Under such conditions the development of real thinking power is simply impossible. We have all found it so. Try to encourage the student to pause in his mad rush long enough to do a little thinking, and what is the result? A late laboratory report or problem, or his lesson for the morrow is not memorized. The instructor's time is also consumed on the other half-cycle of this process. So there is no time for the student to practice scientific thinking, or for the instructor to coach him in it. And the clear reason for this condition is that the educational objective has been one-sided—or at least lop-sided. It emphasizes learning, and not constructive thinking.

And looking to the future, as long as that is the prevailing objective we need not look for much improvement in the thinking power of students and graduates. We may make the learning process more effective; we may approach ever nearer to the most appropriate subject-matter for engineering practice; and we may stimulate teachers to a more active interest in their work. But when we have done all these things, we still have not disciplined and exercised and stimulated the student's thinking powers. We can do this only if we set out to do it. We certainly cannot expect to do it by setting out to do something else.

My proposal is that we modify our objective. Let us definitely recognize the two essential and complementary aspects of a rational objective. We already recognize the one, but it is, unfortunately, to the practical exclusion of the other. I propose that we add the other on an equal footing. Let us affirm that we are going to do two things: first, that we will teach fundamental knowledge and the simpler, essential techniques of manipulation; and, second, that we will coach the student in constructive thinking—in other words, stimulate and discipline his thinking faculties.

THE PRESENT EDUCATIONAL PROCEDURE

We have considered general objectives; in that light let us now analyze the present educational procedure. We build a good, sound foundation of basic physical and mathematical sciences during the first two years; then move over to the next lot and build the house on the sand of technical engineering minutiae.

As a reason why engineering graduates are unable to *use* their physics, mechanics, and mathematics, it has often been suggested that these subjects have not been taught well. I am convinced that this is not the main reason. Instead, it is that the engineering teachers themselves do not use the fundamental principles of these sciences in their class work. They use the definitions and formulas, but that is not using the fundamental principles. Why don't they use them? Because a student cannot apply the fundamental principles of any science in the analysis of a problem or situation without thinking. It is not to be done by memory. And since thinking under one's own power is not fully recognized in the educational objective, it is little done in college programs; and therefore there is no occasion to call these principles out of their mental catacomb. They are consequently forgotten, and that is the reason the graduates cannot use them.

The study of engineering, following the study of basic sciences, thus becomes something almost entirely detached. The graduate leaves college with the basic sciences in one side of his head and engineering in the other. The two have hardly met. Outside of numerous definitions and a few essential concepts, such as symbolism, rates, and those relating to basic physical phenomena—which comprise a necessary basis for the subsequent additional accumulation of engineering learning—there is little continuity between the studies of the first two years and the studies of engineering. Instead of a gradual transition from the learning process in connection with these basic sciences to their application in engineering, there is a substantial discontinuity. And the students, it seems, have consequently come to regard these important, fundamental subjects in much the same category as they classify English and history—merely as courses to be passed off.

When they come to engineering, they turn their attention to new studies. They learn about machinery and structures and perhaps economics. They learn operating characteristics, how to make tests, how to make calculations by formula which apply to certain type-form, fully specified problems. They learn and learn and learn, facts, formulas, rules, and manual technique. The major part of the busy time in American colleges is thus devoted to engineering minuets, in a form and at a tempo set by the instructor.

Our present procedure is therefore hardly conducive to sound and virile thinking in uncertain situations. It prepares, instead, for routine function. I realize, and once more acknowledge, that this description is somewhat exaggerated; there are, indeed, some who try, against almost impossible odds, to bring scientific thinking into their student programs. But I am not talking about these exceptions; I am discussing the situation as a whole, and the fundamental reason why it is so.

There is another pertinent question which should be raised regarding the present procedure. I have mentioned the trend, accelerated by the S.P.E.E., toward a unified program. It has been unified; but unified around what? Subject-matter. Various subjects, practically all relating to engineering, are well ordered in a logical and necessary sequence. Few undergraduate programs in other college courses will match the engineering curriculum on that score. But while the program is unified around subject-matter, the subject-matter itself is not unified in the student's mind. Its different branches seem to remain separate in his mind, just as they were taught, instead of becoming organically articulated to a central stem. And thus much of the memorized subject-matter becomes inert knowledge which clutters the mind.

Subject-matter remains inert until it is utilized in independent thinking. If the multiplication table were learned and then never used in multiplying, it would become as inert as Newton's laws of motion usually are in the engineering graduate's mind. Merely to remember that there is a multiplication table which can be consulted if ever, for some unexpected reason, an occasion arises for its use—this would resemble very closely the usual graduate's state of mind with reference to most of the fundamental laws of basic science. The trouble is not alone that he places fundamental knowledge in such a commonplace category; he seems to have been taught from the point of view that since the character of his future work is not predictable and the possibilities are very wide and numerous, the more subjects he can learn, the higher the probability that he will have included something useful. So the point here is double-barreled. Not only are his fundamentals classified with that other less important knowledge, the possible use of which he regards as highly fortuitous, but, having been learned first, they are at the bottom of the heap. Only fragments of it all are *used*, and most of them are from the formulized top. These fragments are used principally in the exercise of manipulative techniques such as, for instance, the application of specialized, half-understood formulas to fully specified cases. Consequently a large portion of his acquired knowledge—a major portion of it, in my opinion—becomes inert and stays inert.

THE PROCEDURE UNDER A NEW POLICY

Suppose we accept, for the sake of argument, the proposed bilateral educational objective—that the development of thinking power shall be on an equal footing with the development of knowledge and manipulative techniques. What, then, should be our procedure? It should be simply to guide the students as they learn and think in their field, and thus help them to develop that vital central stem, now missing, around which their newly acquired knowledge can be unified. A. N. Whitehead says:

> Education is the acquisition of the art of the utilization of knowledge. This is an art very difficult to impart. Whenever a textbook of real educational worth is written, you may be quite certain that some reviewer will say that it will be difficult to teach from it. Of course it will be difficult to teach from it. If it were easy, the book ought to be burned; for it cannot be educational. In education, as elsewhere, the broad primrose path leads to a nasty place. This evil is represented by a book or a set of lectures which will practically enable the student to learn by heart all the questions likely to be asked at the next external examination.

Let us accept his definition of education, and do away with the primrose path. We must still have a path, but its direction must be properly set.

In order to define the direction accurately, I shall reiterate the five phases of the educational process as I understand it.

1 The first relates to the process of acquiring factual and definitive knowledge. One learns, for instance, the factors in the "flexure" formula in mechanics; the definition of "marginal utility;" that the base of napierian logarithms is 2.718. It is the process of building up one's mental encyclopedia. It is essentially a memory matter.

2 The second has to do with that type of reasoning in which the student is led step by step through logical processes either by a teacher or by a textbook. His part in this particular phase of his journey through the educational forest is not to move precariously along a trail which is only blazed; instead he rides on an educational sight-seeing bus over a modern concrete highway, of which even the curves and grades are reduced to a minimum. His only responsibility is to take due note of the scenery, and of the announcer's comments as he rides along. For instance, he may be thus escorted through the logical development of the "flexure" formula; of the theory of "marginal utility," or of the vector representation of alternating currents. This process is one of civilization's necessary short-cuts. In order to reach the frontier of new things, to acquire on the way an acquaintance with the methods used there, and yet to have a reasonable portion of one's life still available for professional activity, some such rapid transportation seems absolutely necessary. It is a process of vicarious reasoning. In it one learns to follow logically and to retrace the steps; one's mental muscles are developed somewhat, but they do not become sturdy and of good form by purposeful exercise under their own power; instead, they are massaged.

3 The third phase is the process of acquiring skill in manipulation. For example, one develops skill in algebraic transformations; in numerical calculation from formulas by the slide-rule; in operating a machine; or in carrying out an experiment. It is a discipline in manipulative procedure.

4 The fourth phase relates to that type of reasoning in which the student himself takes the initiative. *He* establishes the trail through the educational forest. The objective may, at first, be defined for him, and perhaps its general direction and a few landmarks may be indicated; but he presses through alone. In clearing away the undergrowth, in fording or swimming the technical streams which cross his path, in retracing his steps for a new start when he encounters an impasse, he not only exercises his mental muscles in worthy activity and stretches them to the elastic limit, but also develops his sense of direction and his power of discerning helpful landmarks. Each successive trail thus established by him increases his pioneering powers; and presently he will be able, if it is in him, to blaze his own trail through new areas to new objectives.

5 The fifth phase has to do with the establishment of a natural continuity between the development of the individual at college and after college. The branches of a truly educational program will neither terminate in dead ends here and there during the college course, nor be chopped off at graduation. Instead, they will feed primary educational stems which will both extend and expand beyond graduation as long as the individual is on the ascending slope of his professional career. However, the extension of such stems after graduation is extremely difficult unless the student has already begun to extend them under his own power before graduation. He must develop under guidance both the desire and the power to extend them.

Colleges emphasize largely the first three phases—i.e., acquiring knowledge, vicarious reasoning, and developing skill in manipulation. What I am proposing is that emphasis be shifted to phases 4 and 5—i.e., reasoning under one's own power, and the development of primary educational stems.

In most respects we could follow the procedure of the football coach. Excepting certain aspects of his vehement exhortation, his method might well be used as a pattern. In engineering, as in football, there are certain facts and principles which, experience has shown, must be learned and remembered; and also, as in that game, there are procedures which experience has likewise shown must be understood and sedulously practiced under discipline. The coach not only tells the player how to tackle; he makes him practice tackling under discipline until his muscles become hardened to such use and habituated to proper motion and coordination. And as it is with the muscles, so with the thinking mind. We make a start; we tell students how to make calculations when the data are completely given, and then have them practice doing it. That is good as far as it goes. Let us now do the same thing with thinking.

Just what does this mean? How would you train a student to do independent thinking? I should be presumptuous, indeed, to urge upon the individuals of this assembly any pedagogic formula. My humble purpose is rather to evaluate objectives, and to urge a new direction of emphasis. Every teacher has his own notion regarding detailed method. So all I shall attempt, in this incidental connection, is a sketchy outline of the general plan I have followed for ten years.

EXERCISE OF REASONING POWER UNDER A DISCIPLINED PROCEDURE

The plan is the exercise of reasoning power under a disciplined procedure. That exercise is accomplished in two ways. The first is the application of fundamental principles in the *analysis* of problems; in deducing necessary consequences from known conditions in those cases where such consequences are actually implied; and in establishing probable consequences when the problem and data are less definite. The discipline is accomplished by a *guidance* in orderly and logical procedure. Let me illustrate. In the first place, problems are carefully selected which are suitable for the purpose. After the statement of the problem, the following questions arise: What fundamental principle, or principles, govern the case? What simplifying assumptions must be made? What accuracy is required?

Specifically, what are the conditions which must be satisfied according to those fundamental principles? The answer to the latter question must be a clear, definite statement in English. Then comes the solution. If the problem lends itself to mathematical treatment, that statement in English is merely translated into mathematical language and the conclusions worked out. If not, the conclusions are worked out some other way. In any case, conclusions are reached. Then these must be appraised in the light of the assumptions.

The second means is purposeful and thoughtful writing. Composing component thoughts into a logical, organic whole is a powerful mental discipline. The process requires intense thinking, and if it is repeatedly done under effective guidance, mental power will grow. The engineering student presumably has learned the science of writing—the rules of grammar and rhetoric—just as he has learned the other sciences underlying engineering; but, also like the latter, he has not sufficiently *used* it in thoughtful exercise in his later college work. Consequently, in both cases his ability to utilize effectively the sciences he has learned is unduly limited. Again the similarity of the two cases is strikingly illustrated in the unscholarly writing and speech of engineering graduates. Lack of power and clarity of thought is as much in evidence here as it is in their early engineering practice. I am not making an invidious comparison with the writing of graduates of other courses, but with what I am sure engineering graduates could do if they were effectively coached and exercised in applying the science of composition which they have learned. My proposal with respect to this science is the same as that with respect to the other sciences—that it be utilized in the development of thinking power.

How can a student compose thoughts if he has none to compose? He can't. One of the vivid memories of my college life is a course known among students as "Daily Themes." How I used to strain my mental ligaments every night to squeeze out a thought for a theme! It is enough, heaven knows, to compose thoughts when one has them; it is simply too much to expect a student, under the pressure of a heavy curriculum, to be a spring of original ideas. However, the literature is full of them, and in the engineering courses themselves the subject-matter of reports, exposition, and description provides suitable material for such exercise.

But these proposed means of exercising and disciplining mental power require time. If we now have insufficient time to do what we are attempting, how can we crowd in this additional work which, on an equal footing with the rest, would require a significant fraction of the available time?

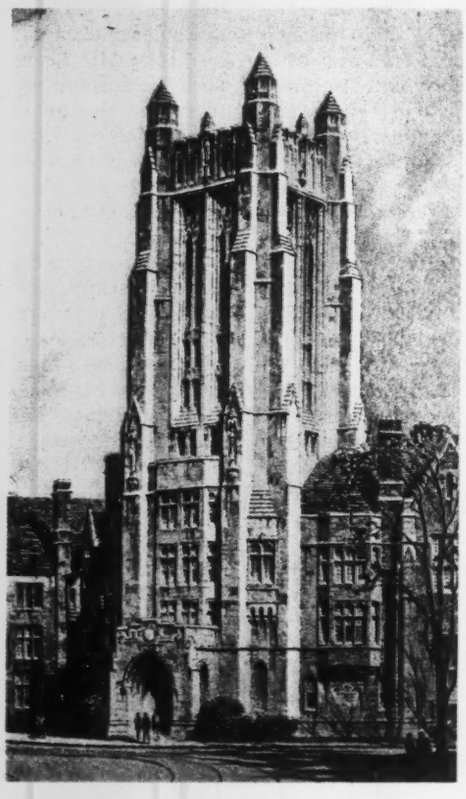
If you have a limited time in which to make a preliminary study and report on some engineering matter, you do not spend all of it in collecting data; you reserve part of it for analysis. You adjust your program to accord with the purpose and the available time. You do not collect all the data you want, and you do not analyze the problem as completely as you wish, simply because you cannot do so in the limited time; but you do get a start on both, sufficient for the preliminary purpose. Then you plan to extend and complete the work later. We have got to do the same thing here. We might just as well recognize that we cannot do all we are doing now and interpose this additional discipline. We must cut down the now relatively overemphasized part of the program to make room for the now underemphasized part. We must balance up. What cannot fit in the junior year must be postponed to the senior; and what cannot fit there will have to be postponed either to postgraduate or postcollege study, and to experience on the job.

However, this process of adjusting the program to accord with both the objective and available time comes second. The primary thought is: What are we trying to do in engineering education?

There is an important distinction which we simply must recognize if we are to keep our thoughts clear on this educational problem. It is the distinction between training engineers, on the one hand, and training students to *become* engineers, on the other. The one is properly done on the job after graduation; the other, in college. It is our job to train them to become engineers. We are not in a position to do the other; and it is, moreover, a very difficult task for the graduate to learn how to become an engineer after he is on the job.

We are in a position to guide the students to a sound scientific foundation; to discipline them to scientific habits of thought in dealing with engineering material and problems; and to engender the ability and desire to extend both after graduation. They will not be engineers when they graduate, but they will be prepared to become engineers very rapidly. With a sound, unified, and active scientific knowledge, and with thinking powers disciplined and tuned to effective action, they will be broadly adaptable. They will be prepared to meet uncertainties of whatever character, and hence to become worthy professional men in whatever phase of engineering they may undertake.

If we are to meet our clear responsibility to train leaders who will be able to cope with the heavy, complex problems of the future, we must modify our educational objective. It is now one-sided; properly it should be bilateral. The acquisition of knowledge and of proficiency in manipulative techniques is only one half; the other is, as Whitehead says, the art of utilization of knowledge. We must add this vital half to the objective. Instead of paralyzing thought by cluttering the mind with inert knowledge which will never be used, and burying at the bottom of the heap valuable fundamental knowledge, let us courageously and carefully eliminate débris and provide in its place the vitalizing and unifying force of independent, constructive thought. We are supplying mental food without vitamins; let us plan to provide these also.



STERLING TOWER, SHEFFIELD SCIENTIFIC SCHOOL

The Problem of ECONOMIC BALANCE

By SUMNER H. SLICHTER[1]

One method of partially offsetting the decrease in spending by business enterprises during depressions is by properly constructed unemployment reserves. . . . . Instead of investing these in securities, let the Reserve Banks be authorized to act as depositories for the funds and let the trustees of the funds be required to deposit them, or a certain proportion of them, in the Reserve Banks. . . . . During booms, when premium receipts exceeded benefit payments, funds would move from the commercial banks into the Reserve Banks, thereby checking the usual tendency of banks at such times to permit an excessive expansion of credit. In times of depression, on the other hand, the excess of benefit payments over premium receipts would cause funds to flow from the Reserve Banks to the commercial banks. This would assist the latter to keep down their indebtedness at the Reserve Banks and to reduce this indebtedness more rapidly. Thus credit would be made easier at precisely the time when this would do the most good. . . . . Some orderly way of providing the unemployed with purchasing power in a manner that will not penalize thrift and will inflict no stigma of charity should be a permanent part of our institutions.

THE question to which I address myself is: "Can we grow steadily?" In other words, can we grow in such a way that the very processes of growth will not destroy the balance in our economic system and thus from time to time produce collapses in business which cause us to lose a large part of the ground that we have temporarily gained? Certainly thus far we have not mastered the art of growing steadily. For every two or three steps upward, we slip back one. I wish that I could justify answering my question with "Yes." Unfortunately, however, the very nature of our economic system precludes this answer. Unless we are willing to make basic changes in our economic institutions, some interruptions to growth appear to be unavoidable. But they need not be so severe, and probably not so frequent, as they have been. In this paper I shall attempt to indicate why interruptions to growth seem to be unavoidable, at least in the foreseeable future, and also how their severity, and perhaps their frequency, might be substantially diminished.

OUR ECONOMIC SYSTEM ONE OF FREE EXCHANGE

The very nature of our economic system, I have said, makes some interruptions to growth inevitable. Ours is a system of free exchange—which means that industry is kept in operation by people freely engaging in the buying and selling of goods. With relatively few exceptions, no one is under legal compulsion to buy or sell. This means that anything which alters the general disposition of people to buy or sell will make the volume of production rise or fall. Under such an economic system, the undiminished continuation of production presupposes general confidence that buyers will not gain materially by postponing commitments. Any condition which creates widespread belief that buyers will gain by delaying commitments will produce a substantial postponement of purchasing and thus a substantial drop in production and employment—in other words, depression. Furthermore, any major uncertainty in the economic situation which merely arouses serious doubts as to the wisdom of spending now rather than later may produce a general decision to await developments, and hence produce a drop in industrial activity. The conditions which may create the belief that buying should be postponed are virtually innumerable. This is why it is ridiculous to be dogmatic in designating this or that as "the cause" of depressions. The cause which you select may be a perfectly valid one from the standpoint of its *capacity* to precipitate a partial breakdown in exchange. But there are many other causes which possess the same capacity and which may precipitate a breakdown before the cause which you designate becomes powerful enough to act. The next time, possibly, it may be your cause which starts the breakdown, and still another time it may be some one else's cause.

A few booms run a rather complete course until they are finally brought to a halt by the inability of bank reserves to sustain a further expansion of credit. Once expansion of credit ceases, a downward spiral in business is almost certain to be initiated, for the simple reason that the inventories which are desirable during a period of rising prices are uneconomically large for a period of stationary prices. When enterprises begin to reduce their inventories, however, the supply of goods is increased and the demand for them is diminished, prices

[1] Professor of Business Economics at Harvard University, Cambridge, Mass.

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begin to sag, buyers hold off, and the downward spiral is set in motion.

Most booms, however, do not go as far as bank reserves permit. They are brought to a halt by some major uncertainty in the economic situation or by some important maladjustment between supply and demand which produces a general shock to business confidence and thus creates a substantial postponement of buying. Please notice the important point that the maladjustment between supply and demand need not be general in order to produce a more or less general shock to confidence and, consequently, a more or less general disposition to delay commitments. For example, an important injury to the economic condition of the farmers, be it a small crop which reduces their purchasing power or an extraordinarily large crop which has the same result, may produce a more or less general postponement of buying. Or it may be a bad inventory situation in a number of important industries—if speculation in raw materials in a few large industries produces too large an accumulation of inventories and hence weakness in the prices of a few important commodities, confidence in prices in general may be undermined, and business may slip into a depression. The overdevelopment of a few of our important industries, resulting in cutthroat competition, may bring about the same result. Such competition leads to sharp drops in some prices, the weakness in these prices spreads to others, and soon confidence in prices in general may be destroyed.

DEPRESSIONS GENERALLY DUE TO CUMULATIVE EFFECT OF MALADJUSTMENTS BETWEEN SUPPLY AND DEMAND

Although a maladjustment between supply and demand need not be general in order to produce a more or less general breakdown in exchange, depressions are not produced as a rule by single maladjustments, but rather by the cumulative effect of a number of them. Theoretically, of course, it is possible for a relatively small maladjustment to spread its effect throughout the economic system. As a matter of fact, however, small maladjustments do not seem to do this because their effect is offset by the discovery of new opportunities to make profits in other industries. But the very passage of time gives opportunity for maladjustments to become greater and for more of them to develop. Eventually their combined effect produces such a widespread shrinkage in buying that it is not offset by the increases in buying which are stimulated by discovery of new opportunities to make profits. It is at this time that a turning point in business occurs.

The fact that maladjustments do not precipitate a breakdown in exchange until they become numerous enough and large enough to offset the discovery of new opportunities to make profit, suggests an examination of the growth of industry itself as a cause of maladjustment. Such an examination will, I believe, be illuminating in showing, not only how maladjustments originate and develop, but also how extraordinarily difficult it is for industry to grow and for the technique of industry to change without sooner or later producing a depression.

At any given time industry is equipped to produce certain kinds of goods in more or less definite proportions. This means that it is equipped to grow in certain ways and at a certain rate. But the very process of growing produces simultaneously (1) changes in the equipment of industry and hence in the kinds of goods which industry is prepared to make; and (2) changes in the distribution of incomes, which means of course changes in the demand for goods. Inventions and technological innovations of all kinds usually have the same two effects: (1) they alter the relative quantities of different kinds of goods which industry is prepared to produce, and (2) they alter the distribution of wealth, and consequently the demand for different kinds of goods. Now if the changes in the productive capacity of industry and the changes in the demand for goods happen to coincide, it will be possible for industry, as equipped, to operate at a profit and for the smooth growth of industry to continue. Here possibly we see a social function in high-pressure salesmanship. It is essential to the smooth running of industry that consumers be willing to demand what industry is prepared to make. High-pressure salesmanship may help to prevent maladjustments between supply and demand, and consequently breakdowns in exchange, by making demand adjust itself to changes in the productive capacity of industry. Of course, if the wrong industries happen to get the best salesman, the effect may be the reverse!

Obviously, however, there is nothing to assure that the changes in the productive capacity of industry will be in harmony with the changed demand for goods which is simultaneously produced by the very process of altering the productive capacity of industry. On the contrary, in view of the fact that the process of changing the equipment of industry produces more or less unforeseeable changes in the distribution of wealth and hence in the demand for goods, it would be remarkable if the growth of industry did not frequently produce serious maladjustments between the kind of productive capacity which industry possesses and the kind of goods which consumers demand. Such maladjustments, by causing prices to sag and profits to shrink, cause a widespread disposition to avoid commitments and thus start a depression. It is inconceivable to me that during the foreseeable future we shall discover how to forecast changes in the demand for goods so completely and so accurately that we shall be able entirely to prevent the growth of industry from creating maladjustments between supply and demand. This is why depressions appear to be a natural and normal, even if not an inevitable, result of industrial growth under a system of free exchange.

THE POPULAR THEORY OF DEPRESSIONS

Thus far in discussing the maladjustments created by technological changes, I have not mentioned the "lack-of-consumer-purchasing-power" theory of business cycles. This is the man in the street's favorite theory

of depressions. Whenever he attempts to construct an explanation of business cycles, he almost invariably ends up with this particular theory. It is not surprising that he does, for lack of sufficient consumer purchasing power is one of the most conspicuous and painful results of depressions. But the fact that lack of adequate consumer purchasing power is one of the *results* of depressions does not, of course, mean that it is one of the *causes*, and the theory that it is a cause is open to serious objection. The theory is usually stated as follows: During prosperity, the incomes of the rich increase more rapidly than the incomes of the poor. Because the rich do most of the saving, the funds seeking investment increase more rapidly than the demand for consumers' goods. Consequently, sooner or later the plant of industry becomes so large that consumers cannot purchase its product at prices which are profitable, and there results a collapse of prices and production.

It is plain that if too much capital is invested in the industries which make consumers' goods, such serious maladjustments may be produced that business confidence is undermined and a general depression sets in. But if the changing distribution of income produces a large increase in savings and, consequently, a large increase in the demand for *capital* goods, why should the increased savings be invested primarily in expanding the plants for making *consumers'* goods? Since the greatest increase in demand is for capital goods, is it not natural for most of the new savings to be invested in expanding plants for making capital goods? If this occurs and in the right proportions, the expansion of industry may go on indefinitely without interruption. Certainly mere change in the distribution of income and a resulting increase in savings do not make inevitable a collapse in production.

Of course it is entirely possible that too much of the new savings may go into some consumers'-goods industries and that these maladjustments may be important in bringing about a general collapse. Indeed, I believe that this result happens during practically every boom. But maladjustments occur in the capital-goods industries also, and these are equally significant in undermining the price structure and in precipitating depressions. Indeed, the very fact that the expansion in the demand for capital goods is more rapid than the expansion in the demand for consumers' goods makes it probable that most of the overoptimistic, and therefore unwise, investment will be in the capital-goods industries rather than the consumers'-goods industries. *But it is the fact that maladjustments develop rather than their location which is important.* In other words, the essential trouble is not that the distribution of income becomes too unequal and that savings increase too rapidly relative to consumer purchasing power, but rather that mistakes are made in investing savings so that the equipment of industry does not adjust itself properly to changes in demand produced by changes in the distribution of income.

It is important to understand this because many people firmly believe that in some way or other the remedy for business cycles is to reduce the inequalities in the distribution of income. Most of us would probably agree that distribution of income is shockingly bad and that there is no social justification for any fortune of over three or four million—certainly none for fortunes of $25,000,000, $50,000,000, $100,000,000, or more. But that does not mean that more equal distribution of incomes is in itself a cure for business cycles. In one way, it is true, more equal distribution might help. Most of the maladjustments between supply and demand which eventually lead to the breakdown in exchange are created by mistakes in investing. Consequently, to the extent that a more equal distribution of income rendered investment less important, it might retard the growth of maladjustments within industry and thus cause breakdowns in exchange to come at somewhat longer intervals. Nevertheless, more equal distribution of wealth would not eliminate mistakes in investing, and therefore it would not prevent business cycles. In particular, it would not relieve us of the problem of guiding investment in such a manner that the growth and changes in the equipment of industry will harmonize with the growth and changes in the demand for products. Furthermore, too drastic limitation of savings might positively cause trouble under some conditions by limiting the ability of industry to adjust itself promptly to important changes in the demand for goods.

HOW OUR CREDIT SYSTEM WORKS

Up to this point I have been talking about a simple system of free exchange. Only once, and then in an incidental manner, have I mentioned the word "credit." My analysis of why there are frequent breakdowns in exchange applies to any system of free exchange, regardless of whether buying and selling are solely for cash or, to a large extent, on a credit basis. But ours is not merely an exchange system—it is a credit-exchange system, in which most buying is financed by credit. Credit is of enormous importance in explaining the failure of industry to grow steadily. It is itself an important cause of maladjustment between supply and demand, and it greatly accentuates the maladjustments which are produced by other causes.

Let us examine briefly how our credit system works. Under a cash system the amount of purchasing power is limited, among other things, by the amount of cash in the community. Under a credit system such as ours, however, the amount of purchasing power may be enormously increased or decreased overnight. This is a result of the fact that loans are made not by transferring money from one person to another, but by *creating* credit dollars, and that loans are paid by destroying credit dollars. The method by which this happens, I shall not explain. Suffice it to say that when the banks make loans, the result is not that the borrowers have so many more dollars and the banks so many less, but that the borrowers have more dollars but *no one* has any less—at least in appreciable amount. When loans are paid, the debtor has fewer dollars but the creditor does not have any more—at least in appreciable amount.

Thus by going into debt we expand the currency; by paying debts we contract the currency.

With this kind of a credit system, when business prospects look favorable the demand for goods is not limited by current incomes—it is increased by borrowing. Unless production expands as rapidly as credit, prices are bound to be inflated. But the banks, creating dollars by the stroke of the pen, can add to the currency far faster than factories and farmers can add to the supply of goods. Consequently the usual effect of a rapid growth of borrowing is a rise in prices. But rising prices result in more optimism and more borrowing, which, in turn, results in still higher prices. Such periods are known as booms. Indeed, a boom might be defined as a period when the community as a whole is going rapidly into debt, and a depression as a period when the community is using a large part of its income to pay debts rather than to buy goods. The advance in prices enables many concerns which would otherwise make losses, to make profits. This conceals the fact that mistakes are being made in the investment of capital and that maladjustments are developing at various points in the economic structure, and tends to prevent the prompt correction of these maladjustments. Furthermore, the very fact that spending is being stimulated by the rise in prices prevents relatively small maladjustments from precipitating a general postponement of commitments and from thus halting the development of maladjustments. On the contrary, only the development of a large number of serious maladjustments will counteract the strong stimulus to spending given by expanding credit and rising prices. This means that the depression, when it eventually comes, is likely to be severe.

If the process of increasing dollar purchasing power by going deeper into debt could go on indefinitely, there would be no serious difficulties. But let the business outlook for any reason become unfavorable and the demand for goods will violently drop, because business enterprises, instead of continuing to spend more than their incomes for goods, will begin to spend less than their incomes and will use the remainder to reduce their debts—which is another way of saying that they will use part of their incomes to destroy credit dollars. Stated more precisely, they will use part of their incomes, not to increase checking accounts of other enterprises or of individuals, but to reduce the loans of the banks. Unless the supply of goods can be promptly curtailed, the old price level is bound to be far too high for the new state of demand. But the supply of goods is not easily reduced. For one thing, many enterprises have inventories which they are anxious to reduce before prices drop too far. Furthermore, both the nature of agricultural production and the economic organization of agriculture prevent a prompt and drastic curtailment of farm output. Finally, the very fact that enterprises have debts which must be paid compels them to throw goods on the market for what they will bring. The inevitable fall in prices, once started, prolongs itself because it strengthens the disposition of business enterprises to reduce their indebtedness rather than to buy goods, and, at the same time, it reduces incomes and causes a larger fraction of them to be diverted to the payment of debts. When the volume of bank loans is as large as is normally the case after a period of boom, the process of destroying credit dollars by paying debts may continue for a long time before the exhaustion of inventories, the impossibility of postponing some buying any longer, the passage of enterprises from weak into strong hands, the gradual accumulation of opportunities to make profits, and other changes in the economic situation eventually become powerful enough to offset the process of liquidation and to produce a revival of demand. If great fluctuations in industrial activity were for some reason considered highly desirable and if we were searching for a way of producing waves of great violence, could we invent a better device than our present credit system?

BETTER GUIDANCE OF CAPITAL INVESTMENT NEEDED

When the causes of breakdowns in exchange are so numerous, one would be a blind optimist to expect that we could entirely prevent depressions. Nevertheless much might be done to diminish their severity and possibly their frequency.

Since the maladjustments between supply and demand are so largely produced by the growth of industry, their prevention or limitation must be accomplished in substantial degree by more discriminating and more informed investment of savings. The basic prerequisite for informed investment is, of course, far more complete and accurate market information than we now possess. Fortunately the importance of this information is gradually being realized, and during the last decade substantial gains in providing it were achieved. The needed data include not merely more complete information concerning sales, production, and inventories, but also information concerning new capacity under construction, the profits of existing enterprises, probable technological changes and their effects on costs, and the prospective trends in demand. Reliable information on most of these points is exceedingly scanty. Rather satisfactory reports on profits and present costs are available for railroads and to a less extent for public utilities, but the financial statements of most corporations in other fields have little meaning. Research of the kind needed to forecast the immediate course of technological change in different industries and the probable demand for different products five, ten, or fifteen years ahead is almost non-existent. Such research is of course difficult to do, and the results will always be subject to important errors and will always need to be frequently revised in the light of new developments. Nevertheless it is unthinkable that we shall indefinitely attempt to operate an industrial system in which the expansion of capital equipment plays such an important part without far more complete, up-to-date, and reliable information concerning prospective trends in productive capacity, costs, and demand. Until we make substantial progress in developing such information, serious

maladjustments between supply and demand in various industries are bound from time to time to produce weakness in prices in general and thus to precipitate depressions.

The obvious need for better guidance of the investment of savings has led to the suggestion that there be established a National Board of Investment. Some persons envisage such a board as endowed with authority to limit the new issues of securities to the volume of the available savings and to ration savings among the various industries which desire to expand their capacity. Others conceive the board to be simply a fact-finding and reporting agency. Obviously controlling the volume of investment and rationing savings among industries are most ambitious tasks and ones which we do not yet know enough to undertake. Furthermore, I have no faith that such a board would consist of men to whom most of us would care to entrust the responsibility of judging between the claims of different enterprises and of rationing savings among them. A strong case can be made, however, for a National Board of Investment which would devote itself solely to assembling and publishing essential information needed in judging the capital needs and the investment opportunities in various industries. So vital is this information that, unless private investors organize to collect it themselves, the Government will be compelled to assume the responsibility.

IMPORTANCE OF MAKING CREDIT CONTROL FAR MORE EFFECTIVE

Possibly even more important than the better guidance of investment is far more effective control of credit. Indeed, as long as violent fluctuations in credit are permitted to produce violent fluctuations in the demand for goods, we are bound to have intense booms and severe depressions. The problem of managing credit falls into two principal parts—its management during depressions and its management during booms. The technique of managing credit during periods of depression so as to limit the drop in prices and to halt the destruction of credit dollars by reduction of indebtedness at the banks is not well understood. It is doubtful, however, whether the instruments at the command of the banking system (such as open-market purchases and low rediscount rates) will ever be highly effective in halting the contraction of credit except possibly in the case of mild depressions. Apparently the avoidance of severe deflation during depressions must be achieved in the main by preventing pronounced inflation during booms. The problem of doing this is more political than economic. Reasonably effective instruments for limiting the credit expansion appear to be available, and fairly satisfactory indexes for guiding action can be constructed. The greatest difficulty seems to be that halting the expansion of credit during a boom is unpopular. Consequently semi-public bodies, such as the Federal Reserve Banks, are disposed to wait until the need for action has become exceedingly clear before acting, and even then to act with undue restraint. The problem, therefore, is to relieve the Reserve Banks in some measure of the necessity for taking affirmative action to tighten credit. One proposal of this nature is to base the reserves of the member-banks partly upon the activity of deposits, so that the reserves required will automatically rise as deposits become more active. Still another proposal I shall explain presently in concluding this paper.

In view of the fact that frequent contractions in expenditures by private business cannot be entirely prevented, the question naturally arises whether they cannot be offset in some measure by an expansion of spending by the Government or other bodies. Cannot the Government arrange to concentrate the construction of public works more or less at precisely the times when private spending is falling off? If the Government raises the funds for public construction by borrowing rather than by taxation, the total volume of spending in the community may be increased. It is important, however, to realize that whether or not a Government deficit has an inflationary effect depends upon conditions. If the deficit is too large and incites alarm, the net effect may be deflationary instead inflationary, because apprehension over the fiscal affairs of the Government may cause many enterprises to defer commitments even more than they otherwise would. The problem which confronts us today and which is likely to confront us in every severe depression is how to handle national finances so as to eliminate the fear caused by a deficit and to derive the maximum inflationary effect from the deficit. Obviously an expansion of Government building during depression is less likely to cause alarm if it is a planned expansion, if arrangements have been made to increase expenditures in advance, and if every one understands that the expansion is merely part of a carefully prepared long-range program.

The deficit which the Government can afford to incur is, of course, far smaller than the shrinkage in private spending which is typical of a severe or even of a moderate depression. One might conclude, therefore, that public construction can be of relatively little importance in mitigating the intensity of depressions. This, however, does not necessarily follow, for the increase in Government spending may be effective in halting the decrease in private spending and thus in bringing the whole process of deflation to a halt. Of great importance, however, is the fact that the expansion of public works should not start so early in the depression that it must be stopped for lack of funds before business revival has commenced. Otherwise the reduction of public construction in the midst of depression may produce a secondary reaction which will be quite disastrous.

UNEMPLOYMENT RESERVES AS A MEANS OF INCREASING PURCHASING POWER DURING DEPRESSIONS

Another method of partially offsetting the decrease in spending by business enterprises during depressions is by properly constructed unemployment reserves. It is plain, of course, that unemployment reserves would

increase the purchasing power *of the unemployed* during depressions. But would not this be accomplished at the expense of the rest of the community? If the reserve funds were invested in securities, as is usually assumed, these securities would have to be sold as benefits were paid to the unemployed, the unemployed would have more to spend, the purchasers of securities would have less, and the community as a whole would have no more. The sales of the securities, by depressing the security markets, would tend to produce a drop in commodity prices. This might dangerously accentuate the depression. There is, however, a simple method of avoiding these results and of assuring that the unemployed would not gain their purchasing power at the expense of the rest of the community. Instead of investing the unemployment reserves in securities, let the Reserve Banks be authorized to act as depositories for the funds and let the trustees of the funds be required to deposit them, or a certain proportion of them, in the Reserve Banks.

HOW THE FUNDS WOULD MOVE

Let us see how this arrangement would work. Employers would pay their premiums to the unemployment reserve funds by drawing checks on the commercial banks, and the trustees of the funds would deposit these checks in the Reserve Banks. Thus the receipt of premiums would tend to transfer funds from the commercial banks to the Reserve Banks. The payment of benefits would have the opposite effect. The unemployed would receive checks drawn on the reserve funds; they would spend the checks for food, clothing, and shelter; retailers and landlords would deposit them in commercial banks; and the commercial banks would present them for payment at the Reserve Banks. Thus during booms, when premium receipts exceeded benefit payments, funds would move from the commercial banks into the Reserve Banks, thereby checking the usual tendency of banks at such times to permit an excessive expansion of credit. Indeed it is probable that, at some stages of booms, funds might flow into the Reserve Banks too rapidly. This, however, would have the highly important advantage of relieving the Reserve Banks of the necessity of taking affirmative action to tighten credit. On the contrary, the Reserve Banks would be compelled to act in order to *prevent* credit from becoming too tight. This they could do by investing more heavily in securities. In times of depression, on the other hand, the excess of benefit payments over premium receipts would cause funds to flow from the Reserve Banks to the commercial banks. This would assist the commercial banks to keep down their indebtedness at the Reserve Banks and would assist them to reduce this indebtedness more rapidly. Thus credit would be made easier at precisely the time when this would do the most good.

This suggestion of unemployment reserves, so constructed that they will increase the total purchasing power of the whole community during depressions and will assist in limiting the extreme expansions and contractions of credit, is an appropriate way of concluding this discussion of economic balance. In view of the fact that serious breakdowns in exchange seem inevitable, some orderly way of providing the unemployed with purchasing power in a manner that will not penalize thrift and will inflict no stigma of charity should be a permanent part of our institutions. Obviously it is desirable that the method of providing for the unemployed throw no additional burden on the rest of the community during depressions, but rather mitigate depressions by supplying the whole community with more purchasing power than it would otherwise possess. Finally, it is fortunate if the method helps us to control that bucking steed, credit, which is so largely responsible for the violence of fluctuations in modern industry. It would be foolish, of course, to regard reserves of the sort that I have suggested as a panacea—they would be far from it. Nevertheless, I can think of no single step which would do more to mitigate the hardships which are the inevitable by-product of attempting to operate a system of free exchange in an uncertain world.

Nesmith

The Trade Association's Part in COORDINATE PLANNING

A Survey of Present and Future Possibilities

By EDGAR L. HEERMANCE[1]

A LITTLE over a year ago, Gerard Swope, of the General Electric Company, called national attention to the trade association as an agency for economic planning—planning of the kind that starts at the bottom and works up, rather than appointing a national planning board and trying to build down. I have been making a survey of the trade associations in order to discover the possibilities along that line, and bring you today a preliminary report.

There have been times in the course of my study when I felt like putting up the sign: "Economic planning closed, pending repairs to the credit system." Overcapacity, which is our most serious problem, is due to the turning of new capital into already crowded industries. The biggest step forward would be control by the Federal Reserve system of the volume of available credit, to keep it in line with the long-term growth of production. That sign has not gone up. Even when credit is stabilized, as I believe it can be, we shall still need the planning of production, to keep it in balance with consumption. A good deal is possible even now.

GROWTH OF THE TRADE-ASSOCIATION MOVEMENT

We have in this country about 500 national trade associations of manufacturers, representing perhaps 1000 fairly distinct groups of products, where the members are in direct competition. The trade-association movement is only about 25 years old. Business men have had to learn how to work together, which has meant both a radical change in habits and the setting up of the proper machinery. Naturally these bodies vary widely in effectiveness. The depression has hit them hard but has set some of them thinking, and apparently there has been a fairly definite shift from the concept of the trade association as a price-protection agency to that of the trade association as a planning board for its industry. I should say that fifty out of the thousand product groups mentioned are ready for the kind of planning I am about to discuss.

Planning must meet five conditions: a product that lends itself readily to forward planning; an overcapacity in the industry that is not excessive—not more than 35 per cent in normal times; a trade organization that is fairly representative; a long training in the fundamentals of good business management; and a somewhat general abandonment of agreements and other forms of price protection, replacing them with a policy of cost reduction in the interest of larger volume and a low but steady long-term profit. Other product groups can work up to planning after a preparatory period. In some cases it will be necessary to scrap existing organizations and form new trade associations or institutes.

What we are witnessing, I believe, is the extension of scientific management from the individual firm to the industry. In the efficient company today facts have replaced guesswork. The business is planned not only for the next season, but as far as possible over a series of years. The market is carefully studied. Costs are known in advance. There is a fairly good idea of the equipment that will be needed and the financing that will be required. Budgetary control has made production much more stable.

INDUSTRY MUST LEARN TO OPERATE ON A BUDGET

An individual company is handicapped in its plans by conditions in the industry of which it is a part. Many of its competitors continue, through ignorance and the pressure of circumstances, to overproduce, sell below cost, and play fast and loose with their capital. If economic planning is to go forward, we shall need a much wider substitution of facts for guesswork. The industry as a whole must learn to operate on a budget. That idea is a little startling at first, but it is only the logical extension of what the more efficient trade associations are now doing after a fashion.

An industry budget will start where the company budget starts, with an estimate of probable sales. What is the total volume of business, broken down into the various lines of product, which the members can expect to do during the coming year, and during the next five years, or whatever period is chosen? If the business lends itself to planning at all, there is no inherent reason why such a sales budget cannot be prepared for the industry just as it is for the company. Past statistical trends are projected on the future. These provisional figures are revised in the light of specific market analyses, technical changes, and general business conditions.

To prepare such an estimate, it will be necessary to set up a properly equipped planning department to carry on various lines of research. Scattered experiments are

[1] Industrial Economist, New Haven, Conn.

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available which only need to be brought together. The trade associations have done some excellent technical research, developing standards, tests, new uses, and better methods. During the last few years, with the help of the Department of Commerce, they have been making market surveys and analyzing distribution costs. There has been some attempt to make an economic survey, to determine the trend of sales in the industry and its relation to equipment and financial structure. It has been demonstrated, I think, that most lines of research can be carried on more thoroughly and more cheaply by the organized group than by even the strongest companies. The typical company, of course, cannot do it all; its production has to be more or less hit or miss—usually miss.

Thus far such joint research has been one-sided rather than complete, sporadic instead of continuous. There has not been the idea of systematic business planning to serve as a focus for research work, particularly along economic lines. The average member has found little help in answering his most pressing problems: what to produce, and how much in order to insure a profit; what investment in capital and equipment will bring a safe return.

If a trade association is ready to spend the money for a planning department (and some of the work could be farmed out to the Department of Commerce and other agencies), it would be possible for the staff to prepare a tentative annual budget for the industry, and also a long-term budget. These estimates would be discussed by the trade group, revised if necessary, and finally approved by the members as statements of general policy. Such a procedure appears to come within the law. There is no agreement. The association does not fix prices or set production quotas. All that the member has done is to join with his competitors in endorsing the judgment of the common fact-finding body that in the ensuing period there will be a certain amount of business for all of them together.

OPERATION OF THE INDUSTRY BUDGET

How would the industry budget operate? From this point on we are on fairly well-traveled ground. Practically everything that a joint budget calls for has been tried out somewhere and found to work.

The efficient trade association has developed market reporting of a high grade. The member-companies report month by month their orders, production, shipments, and so on. This information is consolidated by the central office and sent back to them in the form of a trade bulletin. After such work has gone on for a number of years a company knows its relative position in the industry, and what its normal share of the total business is. Some associations figure out confidentially for each member his percentage on the various items of the report.

With an industry budget, and a knowledge of its relative position, the company knows more accurately than it could know otherwise the amount of business to be expected during the coming year. It knows the range of prices in the industry—there are various ways in which information regarding current prices is being exchanged that are within the law. There is a fairly good chance that the company knows its costs in advance. The efficient trade association has set up a uniform cost-finding system, on the basis of which costs can be exchanged and compared. We have done that for production, and we are now beginning to do it for distribution.

With these various facts before them, each company will budget the largest volume of production on which it can expect to make a profit. Naturally it wants to improve its relative position if it can. The firm which is able to reduce its costs is constantly doing that. But, with this systematic fact finding, there is less danger of a company's trying to advance its relative position from the mere desire for volume, without regard to the situation as a whole.

As the year goes on, and reports from the industry come in month by month, relative position is again a remarkably accurate guide. If the company's orders are found to be running above its average proportion, the cause of this deviation needs to be studied. It may be that its prices are too low and that it is disrupting the market. If its proportion of sales is *below* normal and its prices are not out of line, either its goods are not right or its sales force is inefficient. Corrective measures will need to be applied. The company will watch its inventories, in the light of those for the industry, to see that it is not piling up stocks of slow-moving goods. There is a similar check on inventories of raw material.

THE CHIEF VALUE OF ALL TRADE-ASSOCIATION ACTIVITIES IS EDUCATIONAL

Many trade associations, at least a hundred of them, have set up machinery for that sort of work. It is not being used by the members as much as it should be. The reason, I think, is this: While such reporting is admirably adapted to the needs of companies operating on a common budget, it does not mean a great deal until they do have such a joint budget. There is nothing for the machinery to gear into. The average executive pays little attention to association bulletins, because they do not seem to have any direct bearing on his production problem. The industry budget supplies that necessary connection. It familiarizes him with the idea of budget making and budgetary control. Once start him on those lines, and the monthly reports from the industry cease to be merely additional pieces of printed matter and become useful tools for the operation of his business. It is well to remember that the chief value of all trade-association activities is educational. An industry budget would be worth while if it did nothing more than emphasize some of the fundamentals of good business management. Decisions come to be based on facts rather than on "hunch." Since all competitors are using the same set of facts, there is less danger of actual overproduction. There will be a growing tendency to base production not on capacity to produce, but on the state of the market.

For the industry as for the individual company, the

annual budget needs to be supplemented by the long-term budget. Without that, there is no way of making proper provision for equipment and financing. In the efficient company the budget on which it operates is based on financial requirements over a series of years. We have reached the point where this procedure can be extended to an entire industry. The stabilization achieved by certain units needs to be protected against the instability of other units. The members of the trade association must be trained in long-range planning and given the necessary tools.

The industry's long-term budget will cover three main points: sales, equipment, and financing.

The provisional budget of probable sales during the next few years creates no special difficulty. It is a rough estimate of the market in the light of all available facts. The same methods would be used as in the preparation of the annual budget. Probably the longer plan would be presented in the form of a minimum and a maximum. The newsprint industry of North America supplies the simplest possible illustration. The bulk of its product goes into material for the daily papers. Consumption depends on population growth, newspaper circulation, and newspaper size, which latter is based on the amount of advertising. From present trends it has been estimated that consumption in the United States, which stood at 3,240,000 tons in 1931, will rise by 1940 to a minimum of 3,403,000 tons and a maximum of 4,225,000.[2]

RELATING THE IDEAL CAPACITY OF A PLANT TO ITS ACTUAL PRESENT CAPACITY

What equipment will be needed by the industry to meet the estimate of probable consumption? When this fairly simple engineering question has been answered, the industry's ideal capacity to produce must be related to its actual present capacity. To return to our illustration, the newsprint industry in 1931 was equipped to turn out 5,100,000 tons for the supply of the United States market. As compared with the estimated maximum consumption for 1940 this was an excess capacity of 17 per cent, or, taking the minimum consumption, an overcapacity of 33 per cent. It is clear that no new mills will be required in the next decade, and no enlargement of existing plants. The present distressing conditions in the industry are due to overequipment.

A number of trade associations have made such studies of capacity—cotton-seed products, drop forging, gray iron, public seating. Their reports are worked out in such a way that a company can compare its own figures with those of competitors of the same size or type or in the same geographical area. Whatever the exact situation disclosed by the industry's budget, each company needs to take account of it in making its own plans. Under the circumstances, present and prospective, it may or may not be safe to install more machinery. The management has been given the facts on which to base a judgment.

The equipment question has another phase: the adequacy of present machinery to do the work required. In 1930, 48 per cent of all the metal-working machinery in the United States was more than 10 years old, and for New England the percentage ran as high as 63. Yet the post-war period has seen a steady improvement in machine design. For factory buildings, the same situation holds. In some cases this obsolescence affects an entire trade. They are trying to fight the modern industrial battle with flint-lock muskets.

The Knitted Outerwear Association, with the help of the Department of Commerce, made a study of obsolescence. An inventory was taken of the machines in use by this industry in three large cities. This equipment was then rated by a committee of manufacturers from the standpoint of profit-making efficiency. More than half of the machines were rated at 50 per cent or less. Many machines were being operated only a small part of the time because they were out of date. They could not be, or had not been, adapted to the rapid changes in knit-goods styles. One result of the survey was to discover the need for a uniform cost system and the setting up of reserves for modernizing the machines. Another need was a definite policy in the disposal of obsolete machinery, to keep it from coming back into competition by the second-hand route. By getting rid of such machines, some of the present overcapacity in the industry, with its wasteful competition, could be eliminated.

In the installing of new machinery with a view to cost reduction, care must be taken not to increase the surplus capacity of the industry and the danger of overproduction or idle time. That is where budgeting comes in. Under an industry-budget system, each company knows the total consumption which can be expected, and the capacity required by the trade to carry the load. The facts are so plain that there is no escaping them. The company knows approximately its own share of that consumption and equipment. Planning means the use of these facts to keep sales and output in proper balance. Assuming that no expansion is justified, changes in equipment are arranged so as not to increase volume. The manufacturer no longer has the excuse of ignorance for letting automatic machinery run away with him.

STUDY OF FINANCIAL REQUIREMENTS AN ESSENTIAL PART OF AN INDUSTRY'S BUDGET

A study of financial requirements is an essential part of the industry's budget. There is no mystery about capital structure, though the business man generally thinks there is. When the members of a trade association are ready to open their books for confidential examination, they have taken a long step forward in economic planning. The joint planning department will be able to propose certain financial standards by which each company may check its own condition and policy.

The Millers' National Federation is now doing educational work of that kind. For 1931, 57 members out of 260 submitted complete financial statements. The tabulation is by key numbers, which can be identified only by the member reporting. Such a method has been used

[2] Stanley T. Frame, "Planning for the Newsprint Industry," *Harvard Business Review*, July, 1932, p. 441.

frequently in comparing cost figures. The same striking variations are found here in the statements of various companies on balance-sheet and operating expense. In order to make the figures comparable, they are reduced to a $100 basis, or stated in terms of barrels. The flour-mill operator who finds his items badly out of line with the average for the group, is likely to do some serious thinking. Similar ratios are being used by the Writing Paper Manufacturers and by other trade groups. The United Typothetae have done such work for the printers for a good many years.

THE CONTINUOUS ECONOMIC SURVEY

Broad foundations have already been laid for the application of scientific management to an entire industry. A good many trade associations are well along in the preparatory courses such as cost work, market reporting, and so on. Some of them are now ready to graduate. The postgraduate course on which we are entering requires systematic planning for the industry as a whole. Find out beforehand what the competing companies, taken together, are going to be able to sell, and plan production and equipment accordingly. The basis is the continuous economic survey. The association's reports enable the member to keep in touch with the general situation. Expert service of various sorts is at his call. Each company is put in a position to plan the largest possible production consistent with a safe profit. Machinery and capital can be adjusted to the long pull.

Though the practical difficulties are considerable, the advantages of this joint attack are obvious. Planning for the industry makes individual budgeting more accurate. There is less uncertainty as to what competitors will do. A common budget has great educational value. As time goes on, the exceptions to good management may be expected to be less frequent and less serious. Competition tends to become a race to improve efficiency and service, to reduce costs, to lower prices, and thus increase volume. For the industry in general, profit ceases to be a lucky speculation. It comes to be the return on an investment in production, which may be planned to some extent over a series of years.

In the budgeting for an industry as I have outlined it, intelligent self-interest and the pressure of public opinion within the group take the place of agreement or direct compulsion. Much of the cry for a relaxation of the anti-trust laws is an attempt to escape the consequences of poor business management. The joint budget is a standard or measure of good business practice, no more and no less. You do not enforce a millimeter scale or a British thermal unit; you measure by it. The voluntary acceptance of a standard is much more workable than the idea of compelling companies to join trade associations and conform to certain rules and quotas.

Planning is only another name for good business management. The progress of scientific management will be from the company to the industry, from the industry to the nation, from the nation to the international business world. We are now entering on the second of these four stages. Until industry planning has made considerable headway, national planning must wait.

Ewing Galloway, N. Y.

The Relation of Weather to TRANSOCEANIC FLYING

By JAMES H. KIMBALL[1]

IN LOOKING back to the beginning of ocean flying—and to those who have been intimately associated with this great effort it seems a lifetime—one feature gathers significance with each passing year: the early relation between the pilot and his meteorological consultant. In a way this relation was like that of the family doctor called in to advise a patient on a malady that he had read about but had never encountered at first hand. Both principal and adviser thought they knew the indicated line of treatment, and both were mostly wrong. To one the principal menace seemed to be a failing motor, to the other it was an ocean storm. Now both realize that relatively few disasters are traceable to either of these.

It was impossible for the pilot, even with his wealth of experience in outmaneuvering all sorts of weather, to visualize the devastating influence loosed on his mental and emotional stability after hours of "blind" flying in an airplane made tricky by overloading. How could he adequately appraise his strength in an unending succession of struggles, each depleting a fuel supply known to be barely sufficient and at the same time bringing him, not nearer to a safe landing, but to almost certain destruction?

Improvements in airplanes, motors, and instruments have diminished this hazard, until today reflective pilots recognize that weakened physical, mental, or emotional control is the greatest menace to transoceanic flying.

To the meteorologist, storms are no longer a source of fear, neither is he greatly concerned with adverse winds. Thanks to a more adequate weather-reporting service, he is better able to chart both these great oceanic cyclones and to picture their associated air currents.

It is clouds that both pilot and meteorologist dread today. For who can look with complacence on a flight that must require a long struggle in a blinding, turbulent medium threatening the plane with ice or dismemberment aloft to escape a relentless ocean below?

CLIMATE

It is essential in the preliminary consideration of a flying service to weigh the average aids and hindrances that must be dealt with: to balance one against the other, and their resultant against the capacity of the craft of today. In this way both the routes that are too hazardous and those that are too long may be eliminated.

In a general way the climatic features are well known. Thanks to the thousands of observations made by ships and studied at the collecting centers, the prevailing winds of a large part of the North Atlantic are charted

[1] Meteorologist, U. S. Weather Bureau, New York, N. Y.

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Photographs in this article by Ewing Galloway, N. Y.

for each month of the year. The same is true of pressure and temperature. Other elements such as cloudiness, precipitation, and visibility are not so well known, while the intimate knowledge of storms, so essential for air navigation, is yet to be attained.

Consideration of climatic features is necessary in the selection of the air routes of the future, but this factor can be, and often is, greatly overweighted in the present-day pioneering efforts.

It is well, of course, to know that the prevailing westerlies of the Great Circle Route offer an almost insurmountable obstacle to flight from Ireland to Newfoundland. On the other hand, it is the height of folly to depend on this prevailing wind to counterbalance the inherent insufficiency of the airplane, as was done in some of the early flights. As a matter of fact, however, west winds almost never blow steadily from Newfoundland to Ireland for the period required for a flight. The most favorable wind that can reasonably be expected is one coming from some point in the quadrant between southwest and northwest. Notwithstanding this, the desired wind is most nearly approximated on the Great Circle route.

Further consideration of average conditions suggests a stronger and steadier westerly wind aloft, but high flying runs counter to two other climatic features. Precipitation is recorded in about one-half of the observations received from ships on the Great Circle route, and the percentage of frequency of rain and cloud is of the same order as that of westerly wind. In consequence, high flying means "blind" flying, and the thick banks of clouds so frequently reported by pilots suggest freezing temperatures in their upper levels, even in midsummer.

It is probable that had these climatic features been carefully balanced against the capacity of the plane we should still be in the earliest stage of pioneering. Whether the past cost in lives and equipment will be justified is a problem of the future, but it is a fact that the expenditure of both would have been less had the pilots also been climatologists.

The vast amount of observational data that has been collected in Europe and America has been utilized in the furtherance of water-borne shipping. In consequence, prevailing currents of water and wind are established for all months over the shipping zones; the average tracks of storms for all seasons are known, as are also the areas of greatest gale frequency. However, except in the case of prevailing winds, study has not as yet been carried to the point of determining the frequency and extent of departure from average of these and other elements so essential in the consideration of routes to be used by a type of craft always under the threat of destruction. We must reach further than the question of mere facility of passage which for hundreds of years has been the principal desideratum of water-borne shipping.

The old data must be reconsidered from a new point of view. Literally thousands of observations of clouds made by navigators are in the archives of the meteorological services of the maritime nations, and should be brought together and studied from the viewpoint of the airmen. It is reasonable to conclude that such a study would yield invaluable aid in determining air routes across the Atlantic. Considering only the outstanding promise of such a study—the distribution of cloud types—stratus is a low unbroken layer, characteristic of the northern part of the ocean, while cumulus is one that gives frequent views of the water below or the sky above. Where is the line separating the preponderance of these two types? How does this line swing north and south with the seasons? Where do the stratus clouds most readily merge with fog and mist? And where do those of the cumulus type most naturally rise to the massive thunderhead? It is a matter of fact that, notwithstanding innumerable observations of thunderstorms, we have no ocean chart showing the frequency and seasonal distribution of these hazards most menacing to the airman.

Surface temperatures show a close relation to the amount of clouds, particularly over the Great Circle route, which, except for the corresponding part of the North Pacific, is the most completely overcast large area in the northern hemisphere.

In midwinter the 40-deg isotherm runs from near Cape Race to the Faroe Islands, and thus forms the major axis of this SW-NE zone of deepest cloudiness. In the summer this median line is marked by the 50-deg isotherm. Fifty-degree surface temperature, then, is the critical summer temperature for clouds. Hence weather maps showing temperatures higher than this should be sought if the flier is not prepared to navigate entirely by instruments.

Another simple relation between surface temperature and surface humidity makes possible a fairly close approximation of cloud height. The terms of the equation are the known loss in heat due to progressive decrease in pressure with altitude and the corresponding lapse rate of the dewpoint.

Upper-air observations of temperature have been made for only short periods and in restricted areas. Furthermore, at present there is no feasible method of attacking this problem at sea. However, we do know the temperature lapse rate with altitude under typical surface land conditions, and these must suffice for the present in climatic studies of the ocean

air. The importance of this investigation is made obvious by the experience of fliers in icing at otherwise desirable flying levels, even in midsummer when well south of the steamer lane.

A summer flight of only a few hours over the Great Circle route includes temperatures ranging from the low 40's over the Grand Banks to the high 70's over the Gulf Stream drift. Such differences are probably reflected in the length of the metallic controls and the performance of motors.

These matters have simply been touched on for the purpose of showing the vast amount of labor that the climatologist must perform before well-supported conclusions can be offered to transatlantic flying. But in fear that the matter may seem insuperable to some interested student, the author offers the assurance that near the beginning of his research, and on one of its most needed branches, storm tracks, he will find an invaluable and almost forgotten compilation made by one of the most eminent and painstaking of American climatologists, namely, an early study by Col. John P. Finley, U. S. A. (retired).

Only a few years ago, with the opening of the northeastern Canadian stations, it became possible to learn something of the early ocean experience of American storms after they leave the Newfoundland area. From consideration of the paths taken by these lows as they approach the northeast corner of the familiar weather map, the concept has become more or less fixed that the track formerly maintained is adhered to at least for some distance out over the ocean. Of course many of them do this, but also an appreciable number turn well to the northward. Of the 230 such storms charted for 1930 and 1931, nearly one-half (111) were directed toward the west coast of Greenland or into Davis Strait. This suggests a serious storm hazard to the Arctic crossing, since these storm centers are preceded by strong easterly winds, low clouds, and, for at least half of the year, by temperatures near or below freezing.

Usually it is possible to foresee these storms and to defer the start until they have passed. But this is not the case with another type of storm that comes into the Atlantic from an area almost devoid of shipping and, in consequence, of weather observations, namely, the region south of the line drawn from Bermuda to the Azores. These disturbances are tropical cyclones and usually appear in the late summer and autumn. They cannot be foreseen since they come from an area rarely traversed by ships. Local thunderstorms should also be counted among the hazards of the southern passage, for, be it remembered in passing, it was one of these that damaged the *Graf Zeppelin* on her first voyage to America. Usually in daylight these disturbances may be avoided, but at night their course and extent are difficult to estimate. It was in a group of such storms on land that the *Shenandoah* was destroyed.

TRANSATLANTIC FLYING ROUTES

For the purpose of this paper the Great Circle course is considered to be one that approximates the shortest distance between St. John's and the Lizard. On a Mercator map it appears as a gentle curve that reaches northward to latitude 52 deg 45 min. Its length is 1893 miles, or 35 miles less than that of the rhomb course along the 50th parallel. The greatest distance between the two courses is 165 miles. If, because of drift, the plane diverges from the Great Circle more than this, the advantage is entirely lost. Hence the possible gain in selecting the curved course vanishes when balanced against the increase in cloudiness and the decrease in temperature. It runs through the zone of greatest storm frequency and thickest clouds, and over the famous fogs of the Grand Banks. The total distance from New York to London is approximately 3500 miles.

The route to the north of the Great Circle, the Arctic route, has one important feature to commend it, namely, discontinuity, for no one has yet attempted a non-stop flight over Greenland and Iceland. Unknown weather is here the major hazard. Experience has taught that the 3-hour passage from New York to Cleveland cannot be safeguarded for commercial flight by less than a continuously reporting service from weather stations less than 50 miles apart, supplemented by many intermediate landing fields. Nothing approaching such a safeguard is conceivable for the Arctic route, and without it the crossing with a plane having but a few hundred miles' flying radius will, for a long time to come, be the project of the pioneer. The flight has been made several times from Europe to America, but all attempts in the opposite direction have ended in disaster.

At present, from beyond the thin fringe of Canadian stations north of the Great Lakes and the St. Lawrence, one must fly to the most northerly point in Labrador—Cape Chidley—without definite information of underlying weather. On all the west coast of Greenland there are but two weather stations, a third is on the southern tip of the island, and on the east coast there are but two others. Iceland has two observatories and the Faroe Islands have one. Ships on the water gaps are too few to be depended upon for information.

There is little known of the climate of Davis Strait to commend it. It is a region of frequent storms, low clouds, and freezing temperatures, except for a short time in midsummer. The northeast storms with long periods of cold rains and low visibility are particularly hazardous. Sir Napier Shaw, the dean of modern meteorology,

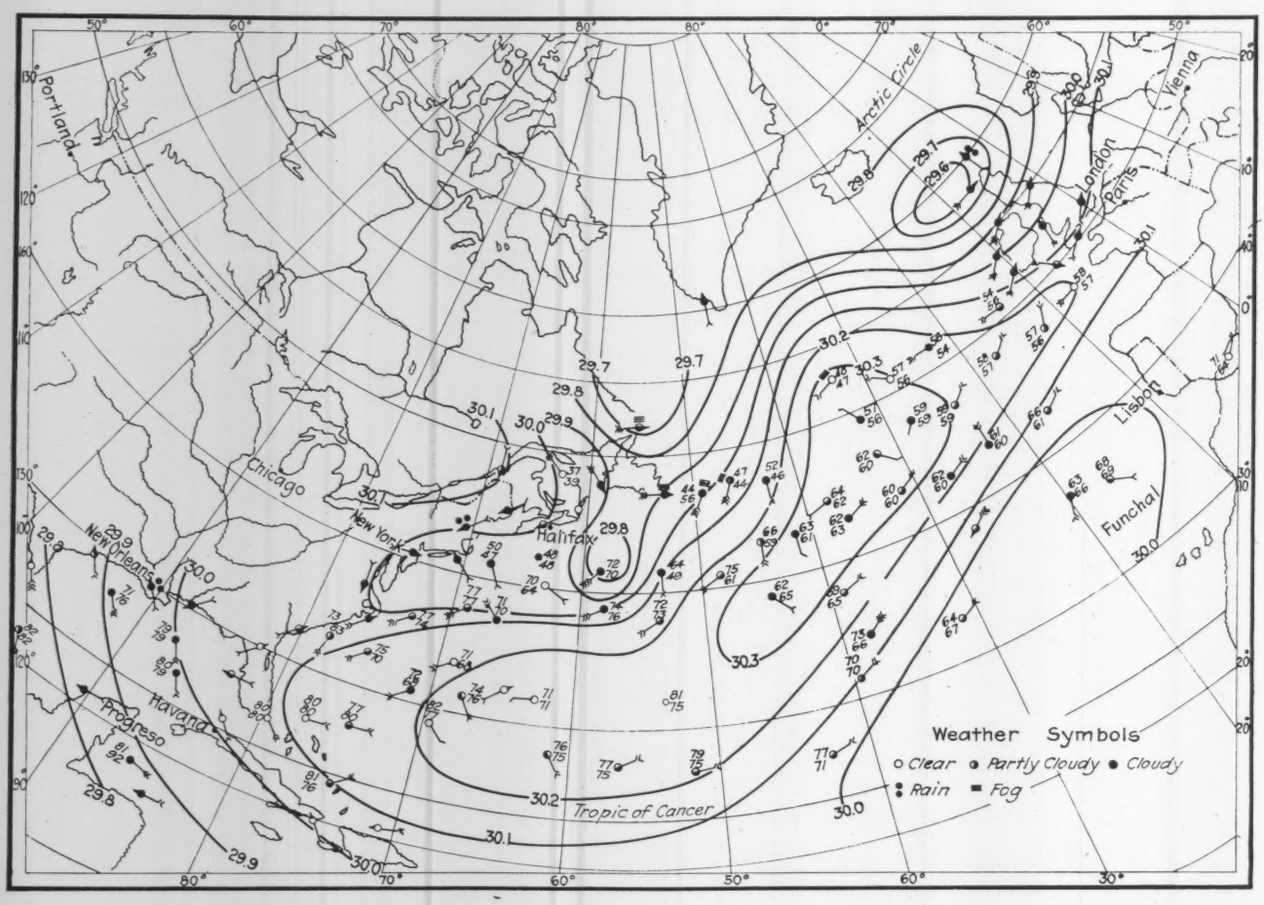


FIG. 1 WEATHER MAP OF NORTH ATLANTIC OCEAN AT THE TIME OF LINDBERGH'S FLIGHT, MAY 20, 1927

[Greenwich mean noon. Isobars show corrected barometric readings in inches of mercury. Arrows fly with the wind; number of feathers indicates force, Beaufort scale. Pointed arrows indicate land stations. Pairs of numbers indicate temperatures of air and surface of water in fahrenheit degrees (upper number, air; lower, water). Weather symbols shown at lower right-hand corner of map. Map reproduced, with some simplification, from the Monthly Weather Review, May, 1927, of the U. S. Department of Agriculture.]

characterizes Davis Strait as one of the "gutters" through which Arctic air drains southward into middle latitudes. Fog and floating ice characterize the Strait of Denmark, which like Davis Strait is a favored area for the southward migration of Arctic air, and in consequence is another of Sir Napier's "gutters."

The remainder of the route, though less precarious, is one of frequent ocean-born storms from the southwest. A clearly defined horizon on this as well as on the Great Circle route is very unusual. This makes the balancing of a plane without instrumental aid very difficult. These obstacles may not be insurmountable, but it will be necessary to complete studies such as those of Hobbs, the Germans, and the British before the course can receive serious consideration by the flying industry.

The course next south of the Great Circle the author has called the "steamer route," because for the first 1250 miles out from New York it follows the course of all European shipping. Thence it is directed to the Azores, Vigo, Spain, and London. It is less stormy than the Great Circle route, less cloudy, and lies south of the fogs of the Grand Banks. But it lacks the advantage of the coastal airway of 1100 miles so highly regarded by pilots for the opportunity it gives in testing instruments and motor, and requires high proficiency in celestial navigation. If competent radio facilities are included, the plane on this course may always be able to reach assistance within a few hours of flight. Weather information may be had all along the route. By moderate alterations in the course it has much promise for two-way travel even in winter. It has been flown successfully by Lotti in the *Yellow Bird* and Yancey and Williams in the *Pathfinder*. The distance from New York to London is 4200 miles.

The southern course via Bermuda and the Azores is the one most promising for all-year-round flying in both directions. But it is beyond present-day airplane performance. Over most of the course the winds are usually not stormy; the air is generally clear, fogs are infrequent, and its storms are mostly local and can be coped with successfully.

However, it cannot be flown by the dead-reckoning method that has been used with astonishing success on the Great Circle. It is too great a distance for a nonstop flight, and the present facilities at Bermuda and the Azores are inadequate. Ships are rarely to be found on

the course except between New York and Bermuda, hence a sufficient weather-reporting service depending on the cooperation of ships cannot be built up along this route. Many of the defects will be removed when and if the Armstrong seadromes planned for it are in place. The distance from New York to London by this route is 4700 miles.

WEATHER

While climatic features such as those already suggested must receive careful consideration in the selection and development of the Atlantic air routes of the future, their chief use at this time is to point out the advantages and obstacles that must be kept in mind in attempting to safeguard the individual flight.

Fortunately in this stage of unpreparedness, the weather problem is invested with many extraneous limitations. As yet, flights that have had any rational planning have been set for the least stormy period of the year, over a route that in fair weather is well within the flying range of the type of plane to be used.

Further simplification might and should be provided by adequate preparation on the part of the pilot in celestial navigation, that he might consider a modification of his prescribed course should a detour be desirable. Few of the pilots who have made the crossing were prepared to do this. The general practice has been to have the course calculated, long before the time for take-off, by some navigator, who also prepares routine for the crossing. Many starts have been delayed because of this limitation. Other projects could not consider even a moderate departure from the shortest course because of insufficient flying radius, while some in their preparation have deliberately counted on wind assistance to make up for this shortcoming.

Periods of storminess anywhere along the course were counted as prohibitive, as were those chartings in which untoward weather appeared to be developing, for the flight could not be properly safeguarded when, for lack of reports, the weather was unknown over a considerable portion of the course. The function of the meteorologist thus became largely one of preventing a start when conditions did not present high promise of success. Obviously such control could only be acquired through the full cooperation of the pilot, his financial backers, and the press. To accomplish this, a continuous series of maps were required, perhaps for a long time before the date set for the take-off, and each map had to be adequately interpreted to the pilot and his associates.

The problem presented two lines of approach: a study of the old maps used by Colonel Finley, and the building up of new ones from reports to be collected by radio from ships at sea. One of the great values derived from these 50-year-old ocean charts lay in the comparison of their anticyclones and cyclones with land highs and lows, particularly their relation in size and intensity, their formation and disintegration, and their courses and speeds.

Before taking up the consideration of the kinds of weather successfully flown by Lindbergh and his successors, it is necessary to note that there was no organized Atlantic weather-reporting service at that time Consequently one had to be provided, and this was accomplished through the cooperation of the Radio Corporation of America and the Independent Wireless Company at the request of the pilots expecting to make the Atlantic crossing. These communication services gave the free use of their facilities in gathering weather observations from ships at sea. The contribution was begun for the preparation of the René Fonck project of 1926 and repeated in 1927. The Weather Bureau undertook the charting of such reports as could be gathered, and their interpretation. Never was it possible to secure a scatter of these observations sufficient to make a complete map, and in only a few instances were reports received from sufficiently near the proposed line of flight to show the weather through which the plane must pass. Thus the interpretation of the map was highly speculative. However, the observations were sufficient to indicate the likelihood of generally favoring winds and the absence of severe storms.

NOTABLE TRANSATLANTIC FLIGHTS

The spring of 1927 saw three projects in feverish preparation for an early start. Weather charting was begun in April, but not until after the middle of May did conditions become settled On the morning of the 19th, all participants were advised that but one stormy area remained. It was then approaching the Gulf of St. Lawrence from the west and appeared to be drawing off to the north, in which case the weather of Newfoundland would soon become such as would make flying feasible. The evening reports of the same day showed dense fog over southern Newfoundland due to the low that at that time had reached the Gulf of St. Lawrence. The depression already had begun to draw off to the northeast.

That evening Lindbergh telephoned for additional advice and was told that the development had gone on during the day as predicted. He took off the next morning at 7:52 from a field made somewhat soft by rains of the preceding night. He passed around a number of small storms over northern Nova Scotia, but found the weather clear over St. John's. He overtook the southern edge of the general storm about dark when over the Grand Banks, but by flying at 10,000 ft was able to keep above most of its clouds. Some of these rose to several thousand feet above him, and in attempting to pass through one, ice formed on the wing of his plane. Thereupon he turned back for a new approach. During the remainder of the night he protected himself against this hazard by flying around clouds that he could not fly over. The wind was westerly during the entire crossing, and of sufficient force to produce whitecaps on the waves. This was the situation along the slope of a high that extended from the south to the portion of his course lying east of the Grand Banks. Lindbergh demonstrated the fact, not before known, that a non-stop crossing with the airplane of his day was possible provided the pilot was blessed with

soundness of body and great mental and emotional stability.

The same general type of map was selected for the Chamberlin flight beginning June 5, but the course to be flown was a straight line out from Cape Race. The course lay more than 150 miles south of the most northerly point of the Lindbergh route.

Chamberlin contributed to the technique of transatlantic flying by showing the futility of attempting the Great Circle, with all its complicated navigation, its lower temperature, and greater cloudiness for the inconsequential advantage of about an hour's flying. He showed that by following the straight compass course, making allowance only for changing magnetic variation, his drift problem was simplified, and he also was in an improved stragetic position in navigating the southward extensions of storms centered north of his course. Probably none of the transatlantic projects was prepared under such hectic conditions, and it is greatly to Chamberlin's credit that he was able to preserve his mental balance in those times. He confirmed Lindberghs' experience, and in addition he carried a passenger and established a new distance record.

The Byrd flight, which for a time gave promise to be the first, was the last of the non-stop crossings that year. His preparation showed all the skill of his great experience. No conceivable safeguard was omitted, and to this was added a high sense of responsibility for the welfare of his companions. There were four in this group: Byrd, in command, handled the navigation; Acosta and Balchen did the piloting, and Noville had charge of the radio. All four were competent pilots. The official purpose of the flight was to carry mail to Paris.

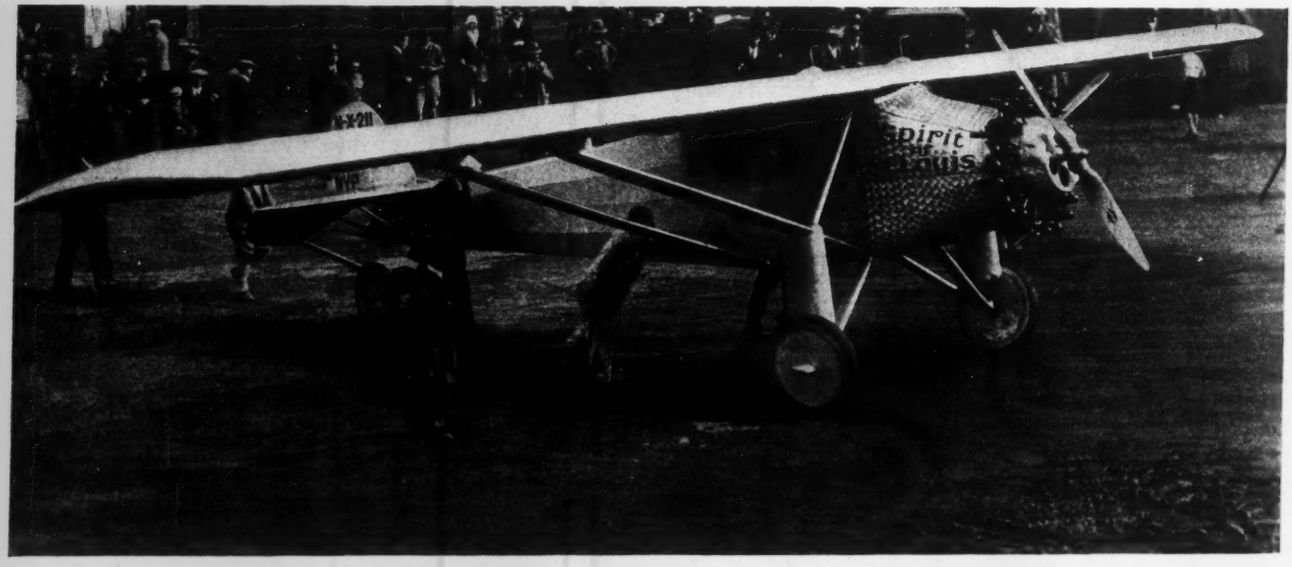
Profiting by the experience of his predecessors, Byrd chose a compass course slightly north of east from St. John's to about mid-ocean; then a series of 500-mile straight flights, each deflected a little more to the south, the last leading directly to the southwest point of Ireland.

The flight demonstrated the possibility of carrying a pay load across the Atlantic, and it emphasized the need of celestial navigation, a co-pilot, and the radio. The thrilling features were the superb take-off by Acosta and the safe landing on water in the dark by Balchen.

A number of other crossings were made over the northern route, each contributing a valuable share to flying technique, but it was not until the spring of 1929 that it was considered reasonable to attempt the longer water hop lying farther south. The interval saw a marked advance in plane and motor construction. Balanced against the shorter distance and the decided advantage of a flight about one-third of the way lying along the shore to Cape Race, was the flight directly east for 1200 miles along a course much frequented by shipping. Many of the vessels on this stretch proceed with clocklike regularity, and these if charted afford nearly fixed points upon which the progress of a flight may be checked. But in order to take advantage of these aids, celestial navigation is essential. Assistance also would be not far distant in case of need. The course is desirable since it lies south of the fog banks, has generally clearer air, and is somewhat less stormy. Two projects essayed to fly this course. Both elected to start from the beach at Old Orchard, Maine, where, at low tide, a long, hard runway is available. Lotti, in the French plane *Yellowbird*, was the first to take off, the departure being on June 13 at 9:08 a.m. A 600-hp Hispano-Suiza motor successfully lifted a total weight of $6\frac{1}{4}$ tons, more than twice the gross weight of the *Columbia* flown by Chamberlin.

When about 20 miles out from Old Orchard, fog was encountered. The plane was elevated to a level of

(Continued on page 143)



LINDBERGH'S PLANE "SPIRIT OF ST. LOUIS," BEING MADE READY TO TAKE OFF FOR PARIS, AT CURTISS FIELD, LONG ISLAND

NEW CONSTRUCTION *Can* RESTORE PROSPERITY

By DAVID CUSHMAN COYLE[1]

MR. HARWOOD'S paper in the December issue[2] seems to call for some comments, since it seems apparent that he has not understood my position. In the first place, it is a satisfaction to find that we all agree on the desirability of some program of public works in depression. Since that is the first thing to be done, and since the approaching change of administration will apparently improve the chances of its being done, there is some hope of getting started, at least, along the road to recovery. As to the meaning of the process and the further measures that may be necessary, that is where the fight begins.

Mr. Harwood has set forth the variant of the Hobson theory which I have advocated, in a form suitable for easy demolition; but not in the form which I believe to be valid. On p. 838, second column, he attributes the following opinion to me: "The initial difficulty and cause of the depression is that savings accrue at a faster rate than investments are made. Therefore there is a failure of purchasing power coming to market to balance the flow of goods." Of course this is not true, and Mr. Harwood can prove it is not. What is true, however, is that savings are made at a faster rate than the real need of new plant to take care of the growth of the market for goods. Investments not only keep up with savings but exceed them by the addition of bank credit—inflation in the sense that Mr. Harwood uses the word. Incidentally, Mr. Harwood apparently believes that I agree with Foster and Catchings. I do not.

Mr. Harwood goes on, explaining Hobson: "If these excess savings are invested in more plant equipment . . . the result will only be to flood the market with more unsalable goods." This may be more or less true, and he makes no attempt to discredit the idea completely. However, it is the least important feature of the process. What really results from the investment of excess savings is: (1) encouragement to inflate bank credit and add it to the excess; (2) a considerable excess of production capacity. Only to a minor degree does the excess appear as actual overproduction. In the main it appears as intensified competition, rising selling costs, and dropping prices—the so-called "profitless prosperity."

This explanation of the process that leads to the collapse of a cyclical boom "overlooks" the subsequent deflation, as defined by Mr. Harwood. This is because credit deflation, i.e., the reduction of investments below savings, is not the main process but an aggravation of it due to the behavior of bank credit.

Mr. Harwood then proceeds to state that at a time when business is under deflation, and current incomes are being called upon to pay up and wipe out previously contracted debts, it will do no good to tax those incomes and try to add the tax to purchasing power. The idea is that purchasing power is being destroyed by the retirement of bank loans, and that the process cannot be affected by manipulating the remaining purchasing power. True, but irrelevant. The time for taxing incomes is not in depression but in prosperity.

The picture of the cyclical process which seems to me to be valid includes Mr. Harwood's inflation-deflation mechanism as one of its parts. In boom times too much money is saved and invested, and bank credit is inflated and added to the investment total. These investments are a debt on business, represented in material form partly by excess plant capacity, and partly by excess stocks of goods and raw materials purchased at high prices. During the boom the process of investment provides purchasing power to the building and machinery trades. This purchasing power is not free and clear, however, for debts have been created, to be paid, if possible, out of future purchasing power.

This is the standard normal method of distribution of purchasing power, believed by most bankers and economists to be inevitable and necessary. No restriction is placed on saving; and "sound" financial practice requires that savings must not be dissipated in riotous living, but invested, with the erection of corresponding debts. Since business has not an unlimited capacity for carrying debt, the excess (together with the further excess imposed by bank-credit inflation) has to be wiped out by capital losses. A depression is an automatic readjusting mechanism by which business throws off its excess load of debt. The distribution of purchasing power occurs during the boom, when the investments are being made. The excess savings are turned into consumer buying power, and the corresponding stocks and bonds lie in the bank box as unrealized losses, to be realized during the subsequent crash. Bank-credit inflation and deflation merely ride on the back of this fundamental process, aggravating its effects both up and down. They may also serve as an indication of what is going on, as Mr. Harwood believes.

THE TWO PARTS OF THE PROPOSED REMEDY

Now the proposed remedy for the main cyclic process has two parts. The more fundamental one is the imposition of heavy taxes on the "upper brackets," collected, naturally, during good times, so as to cut the amount of savings. The result of that measure will be to turn these savings into current consumer buying power—the same thing that is done by investing them—but *without* imposing any debt on business. Incidentally, it will also be likely that if actual savings are not pressing hard into the investment market, bank credit will not be so liable to inflate. Since the major cause of a crash is that there are too many debts, this process which retards the growth of debt will retard and soften the crash.

The second part of the remedy is a temporary device, required only because there is, as Mr. Harwood says, no way to get any considerable taxes out of the people during depression. That is quite simply to reverse by deliberate application of force the natural inflation-deflation cycle, by creating bank credit now for use in public works, and destroying it by means of income and inheritance taxes as soon as prosperity is brought back. The significant distinction between Federal debt and

[1] Consulting Engineer, New York, N. Y.

[2] "Can New Construction Restore Prosperity?" by E. C. Harwood, MECHANICAL ENGINEERING, December, 1932, p. 837.

business debt is that the Federal Government has the power to choose who shall pay the debt. It can throw the burden on wealth and thus prevent it from resting on consumer buying power.

The reason many financial thinkers cannot see any chance of getting back to prosperity until the deflation has run its course, is that they are unable to visualize any kind of prosperity that is not founded on the standard mechanism of building up a new debt structure. Naturally, if new debt building is the only way to be prosperous, the old debts must be defaulted in order to make room for the building of new ones. But prosperity salted with sufficiently heavy income taxes does not need to involve any large debt-building process, and when that is understood it will be plain how prosperity does not need to be paid for by drastic doses of bankruptcy.

WHY THE FORCED-CONSTRUCTION PROGRAM OF 1930 FAILED

The forced-construction program of 1930 failed for just the reason stated by Harwood. Some of the new work was industrial, and its cost was added to the debt structure of business. Some was municipal or county work, and the bonds with which it was financed rested on the shoulders of local taxpayers. Now, the local taxpayer is generally none other than our friend the "consumer," the person to whom business looks for its income. So these local public debts were also, indirectly, a burden on business. All of that got us just nowhere in the way of liquidating the excessive load of debt that had to be deflated.

If the Federal Government had forgotten its noble sentiments about rugged individualism and paid for a big program of public work, it might just possibly have been able to stop the depression in 1930, provided the bonds were to be paid solely out of the higher brackets after the restoration of prosperity. But the recovery would have carried over into the good times the partly undeflated debt structure, and quite likely that was too much of a load to make recovery possible then. Now, however, the debts of business are somewhat better deflated, and by the time any new program can be gotten into action they will perhaps be scaled down to a fairly safe total. The soundness of the new program will depend mainly on its ability to keep the new Federal debts from being placed on business or on the consumer.

The foregoing, however, is not the most serious misunderstanding that comes from attempting to apply old-fashioned economics to the existing situation. The fact is that, as Mr. Harwood says, "the impact of technological changes is largely concentrated in periods of subnormal business." The difficulty is that this time it has sunk the business cycle itself. The new continuous-process machines are only in their infancy, and their effect is being aggravated by changes in metallurgy and in the use of non-metallic materials that promise violent reductions in consumption obsolescence. The result is that a small amount of new investment money will build a continuous-process machine that will wreck a large amount of existing plant and will do it very promptly. Moreover, a few weeks' employment of a few dozen men, building one of these machines, will put several thousand of the cyclically unemployed on the permanent list.[3]

What this new development does to the standard cyclical mechanism of recovery is pathetic. The whole standard process was built on the fact that investment and loss were separated far enough to keep the investors in a state of simple-minded hope, so that they would turn their savings into consumer buying power, unconscious of the fate awaiting their stocks and bonds. Now the openings for new investment are diminishing, while the necessary consequent bankruptcy is increasing in speed and volume. The veil is too thin. Moreover, who is going to build, let us say, dial-telephone exchanges fast enough to employ as many men as the number of operators displaced, and how long can it be kept up?

The fact is that the standard process of expansion was a geometrical progression, and the standard depression was a rough and painful, but effective, device for setting it back every so often. Now the continuous process has accelerated the ratio of the progression to such a fantastic figure that the old mechanism of investment and loss is too painful to continue. The victims, both investors and unemployed, refuse to play their parts with patience. Something new has to be done.

SAVINGS MUST BE TRANSLATED INTO CONSUMER PURCHASING POWER WITHOUT FURTHER DEBT CREATION

The new thing that must be done is to substitute another mechanism for spreading savings or potential savings out into consumer purchasing power without creating fantastic bodies of new debt. Mechanical industry is now ready to expand quickly to the physical limits of our available natural resources. After that there will be left a very large body of unemployed. They cannot be employed in setting up and taking down great quantities of buildings and machinery, because the investors are not callous enough to put in and lose savings at the necessary rate. Therefore the excess labor must be occupied in the so-called "services" market, making cultural or quasi-cultural improvements that require only time, brains, or labor, but that do not use up significant amounts of material or power. The way to get that process into action is to take savings or potential savings and put them into public or semi-public services by means of the income tax and by contributions stimulated by the tax laws. That is why new construction will restore prosperity if it is financed in the right way, and that is why a drastically increased program of cultural advance, paid for out of higher incomes, will keep prosperity going.

After we have taken these fundamental measures, it will be time to take up Mr. Harwood's method, if it can be proved to be valid, and establish a credit control that will prevent the banks from aggravating the remaining fluctuations of business. But before we give too much attention to putting a gyroscopic stabilizer into the boat, we had better take the necessary measures to keep the craft from drifting bodily over the falls.

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[3] See Hoover Committee Report; "Recent Social Trends;" also F. C. Mills, "Economic Tendencies," National Bureau of Economic Research, 1932.

STEAM RESEARCH

Progress of Work at the Massachusetts Institute of Technology[1]

I—By F. G. KEYES[2] and L. B. SMITH[3]

DURING the year an entire new series of measurements on the volumes of liquid water under pressure have been carried out in a Nirosta steel container. The earlier series reported in previous meetings had been made in the pure nickel container and the chrome-vanadium steel container. The results of the new measurements accord very well with the older data, and Dr. Smith describes the new data in some detail in a succeeding report.

It will be recalled that the method practiced to secure saturation values of both the liquid and the vapor phase has been to extrapolate the volumes of each homogeneous phase to the saturation pressure. In the case of the liquid at lower temperatures this is quite simple, but increasing care must be exercised at the higher temperatures. Dr. Smith has devoted much time to the actual testing of a number of empirical equations expressing the volume as a function of pressure at constant temperature, and several of these equations have proved satisfactory. It seems very probable that the liquid volumes of water are now known with a very high degree of precision to over 300 atm pressure.

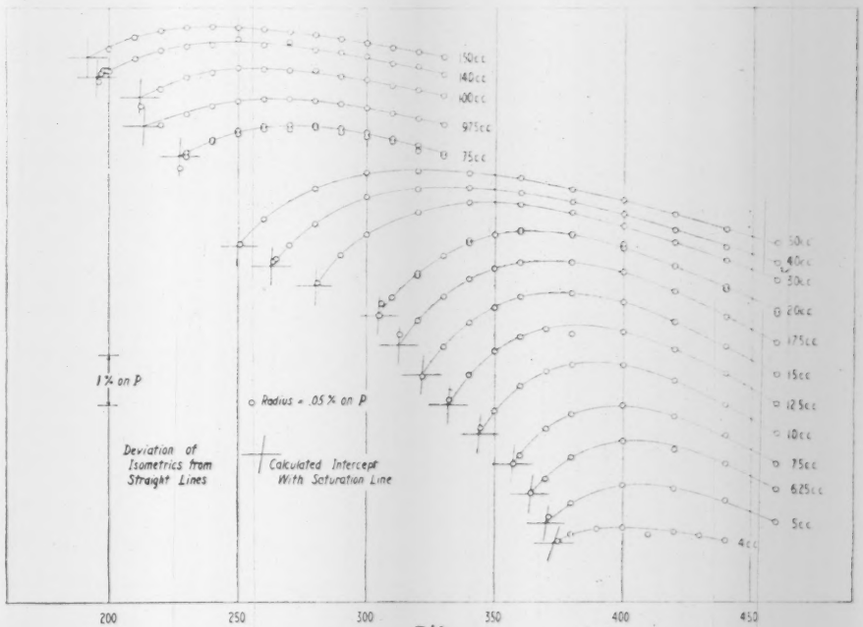


FIG. 1

In the case of the vapor phase a considerable body of data now exists, there having been added during the year new values of the pressures at 2 cc, 3 cc, and 4 cc per gram at temperatures extending to 460 C. The addition of the latter data "rounds" the steam dome completely and closes the gap that formerly existed. Each datum on the vapor phase has been reexamined and a new graphical extrapolation of the isometrics to the saturation pressure and temperature carried out. The new values differ somewhat from those reported in the February, 1931, issue of Mechanical Engineering, p. 133. Such differences as exist are largely connected with experimental redeterminations of the saturation pressure-temperature relation carried out during the year. As a matter of fact, the measurements of saturation pressures carried out in nickel, steel, and chrome-vanadium steel containers have never left us entirely satisfied that some error did not enter due to the known slight interaction between the container material and water. During the year Drs. Osborne, Stimson, and Fiock were also observing saturation pressures. We have kept in touch with one another and, while an actual intercomparison of data cannot be presented at this time, it is satisfying to know that the results of the two independent sets of data are in excellent agreement notwithstanding differences in experimental procedures.

In Fig. 1[4] there is given a graphic representation of all the isometrics which can be extrapolated to the saturation pressure and temperature. We now possess pressures and temperatures for the isometrics very close to the saturation condition. The method used in the measurements may not be supposed to be free from effects arising from adsorption of water on the walls of the container at volumes larger than 150 cc per gram There is, however, no positive indication of appreciable adsorption at the saturation temperature (191.93 C) corresponding

[1] Contributions from the Research Laboratory of Physical Chemistry, Massachusetts Institute of Technology, Cambridge, Mass. Serial Nos. 296 and 297.

[2] Director of Research Laboratory of Physical Chemistry, Massachusetts Institute of Technology.

[3] Assistant Professor of Physico-Chemical Research, Massachusetts Institute of Technology.

Contributed by the Special Research Committee on Thermal Properties of Steam and presented at the Steam Tables Session of the Annual Meeting, New York, December 5 to 9, 1932, of The American Society of Mechanical Engineers.

[4] In order that the entire body of superheat volume data greater than the critical volume could be completely placed on a single diagram, the pressures and temperatures for each isometric were plotted as percentage pressure deviations from linear equations passed through two points on each isometric. In general a different scale has been used for each isometric, but the diameter of the circles representing each experimental point corresponds to 1 per 1000 in the pressures. The values of the saturated-vapor volumes from the original graph were correlated as a function of temperature, and these smoothed values were used (undesignated) as points through which the full lines pass at saturation. The intersections of the saturated pressure-temperature values are designated by large crosses.

to the latter volume, but the measurements taken close to the saturation temperature are certainly the most likely to be affected by adsorption if adsorption exists. It will be noted in each case that there is no particular evidence of a sudden dropping off in pressure as the saturation temperature is approached. Of course, the adsorption effect may be present in spite of the smooth and regular character of the isometrics near saturation. The chief reliance for the supposition that the adsorptive effect is small in the neighborhood of 200 C rests on the knowledge that the amount of water vapor adsorbed at low pressures diminishes rapidly in passing from ordinary temperatures to higher temperatures.

There are at least two ways by which direct confirmation of the saturation values could be secured. The first is through employment of the principles of thermodynamics, using the heat-of-evaporation measurements of Osborne, Stimson, and Fiock. The second is to devise a new and independent experimental method where adsorption plays no part.

The pressure-temperature data have now been smoothed and accurate values of the change of pressure with temperature are available for use in Clapeyron's equation $L = T(dp/dT) \times (v_1 - v_2)$, where T is the thermodynamic temperature, and v_1, v_2 the specific volumes of the saturated vapor and liquid at T. It may be recalled that last year the author (F. G. K.) referred to the difficulty of using the Clapeyron equation with confidence because the uncertainty in the relation of the temperature scale of the platinum-resistance thermometer to the thermodynamic scale. In view of the precise character of the steam data the relationship becomes especially important. In the strict sense, of course, the use of any scale of temperature other than the thermodynamic in a thermodynamic equation is unwarranted or even meaningless.

During the course of the year a third investigation by Drs. Beattie and Gaines of the relation between the platinum-resistance scale of temperature (International Scale) and the helium- and hydrogen-gas thermometers has been completed for the range 0 to 100 deg. The earlier findings are entirely confirmed, but the new results are much more precise. The result, as it relates to saturation vapor volumes obtained through the Clapeyron equation, using the International Scale, is that V_{sat} differs at 100 deg from the volume similarly computed, but making the corrections required to reduce dp/dT to the absolute scale, by about one part in two thousand. The deviations will undoubtedly increase as the temperature rises, but final gas-thermometry data at higher temperatures are not yet available. It is quite evident at present that no final judgment regarding thermodynamic consistency is possible until the temperature-scale relationship is established. While waiting for the experimental data we are proceeding with the correlation of the pressure-volume temperature data for the homogeneous vapor phase.

The second way to obtain light on the reliability of the present saturation volumes is to make use of the flow method for the determination of volumes. Something a little over two years ago Dr. S. C. Collins and the author (F. G. K.) attempted to measure $(\partial H/\partial p)_T$ directly. As our efforts continued it began to appear that it would be possible to measure the change of the heat function with pressure quite accurately where the change is negative. In the case of steam $(\partial H/\partial p)_T$ is negative until very high temperatures are reached (T about 1200 C for very low pressures). The two substances used in the work of perfecting the method were ammonia and carbon dioxide.[5] At the moment the apparatus is being entirely reconstructed with improvement in design, and it is hoped that values for $(\partial H/\partial p)_T$ for steam can be obtained for 30, 50, 100, 125, and 150 C.

At the time that experiments were begun to determine $(\partial H/\partial p)_T$ directly, the attempt was also made to measure the Joule-Thomson effect at low pressures by a modification of the usual porous plug. This work was sufficiently successful in the case of ammonia and carbon dioxide to warrant the attempt to determine the coefficient for steam at low temperatures. If this work succeeds it will be possible to obtain values of c_p at low temperatures by making use of the relation:

$$c_p = -\frac{(\partial H/\partial p)_T}{(dT/dp)} = -\frac{(\partial v\tau/\partial \tau)_p}{(dT/dp)}$$

The quantity $(\partial H/\partial p)_T$ is thermodynamically equivalent to $(\partial v\tau/\partial \tau)_p$ where τ represents T^{-1}. Consequently since $(\partial v\tau/\partial \tau)_p$ is known to be negative for steam until very high temperatures are reached, our method provides in effect a means of obtaining specific volumes. To demonstrate this, use is made of the experimental fact that the available p-v-T data indicate that the quantity $(\partial H/\partial p)_T$ is equal to the following function:

$$\frac{\partial H}{\partial p} = \varphi_0 + \varphi_1 p + \varphi(p\tau) = \left(\frac{\partial v\tau}{\partial \tau}\right)_p \quad \text{..... [A]}$$

It follows then that if φ_1, a pure temperature function, and $\varphi(p\tau)$, a function of pressure and temperature which vanishes for $p = 0$, can be represented, as they have been for the p-v-T steam data available, then

$$v = T\int \varphi_0 d\tau + \tau p \int \varphi_1 d\tau + T\int \varphi(p\tau)d\tau + f(p)$$

It also is to be observed that the H-function may be obtained by integrating [A] and

$$H = \varphi_0(p - p_{sat}) + \frac{\varphi_1}{2}(p^2 - p^2_{sat}) + \int_{psat}^{p} \varphi(p\tau)dp + f(\tau)$$

It is hoped that actual experimental results can be reported at the next steam-table meeting.

II—By L. B. SMITH[3] and F. G. KEYES[2]

SINCE the 1931 meeting new measurements have been made of the compressibility of liquid water from 30 C to 374 C. The 2-, 3-, and 4-cc-per-gram isometrics have also been measured, thus completing our knowledge of the p-v-t relations around the steam dome. Finally, measurements of the vapor pressure of water from 150 C to 370 C have been repeated, using for this work a new apparatus specially designed for the purpose.

These new vapor-pressure measurements have been correlated by means of a single equation covering the entire range from 100 deg to the critical temperature. Fig. 2 shows the difference, expressed in parts per ten thousand, between the calculated and the observed pressures. Differences from the smoothed values presented at the 1930 meeting are also shown. The curved lines represent the differences that would result from an error in temperature of plus or minus 0.02 C.

Fig. 3 shows the differences, in parts per thousand, between

[5] F. G. Keyes and S. C. Collins, Proc. Nat. Acad. Sciences, vol. 18 (1932), p. 328.

our new and old saturated specific volumes of the liquid and between our new values and those given in the Keenan tables.

At 300 C and above these latter differences are too large to show on a convenient scale, and amount at most to about 5 per cent at 360 C. The magnitude of these differences is not surprising as at the time the tables were compiled only very incomplete information on saturated liquid volumes was available.

Our old compressibility values are in far better agreement with the newer ones than might appear from the differences in the saturation values above 300 C. This is attributable to two causes: First, the older values were obtained by extrapolation of the compressibility measurements to appreciably higher vapor pressures than those now accepted; and, second, the older method of graphical extrapolation has recently been found to be quite inadequate.

In correlating the new liquid volume isotherms a large number of different equations have been tried with varying degrees of success. At the lower temperatures the volumes of the compressed liquid may be represented quite simply by a quadratic or by a cubic of the form

$$v = v_s + b(p - p_s) + c(p - p_s)^2 + d(p - p_s)^3$$

At the higher temperatures, however, the most satisfactory form of equation appears to be

$$v = \frac{v_s + bx + dx^2 + cx^{1/2}}{1 + cx}$$

where $x = (p - p_s)$. This equation represents the different liquid isotherm values with an average deviation of only 10 to 30 parts per million, thus exhibiting a consistency much in excess of the probable absolute accuracy of the measurements. As yet no attempt has been made to represent the different constants of the equation as functions of temperature, but it is hoped that this may be accomplished, thus giving us a complete equation of state for the liquid phase.

Fig. 4 shows at a glance the extent of the M.I.T. *p-v-t* measurements. The coordinates are pressure and log volume. The shaded area and the curved lines to the left and above the steam dome represent the liquid measurements. The heavy vertical lines above the dome represent isometrics of high density, and the shaded areas to the right of the dome are the regions covered by the superheat measurements at specific volumes from 5 to 150 cc per gram. The curve forming the dome itself repre-

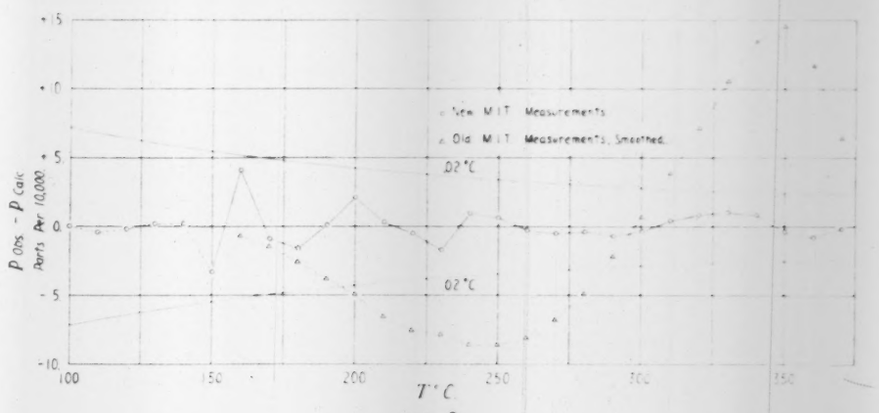


FIG. 2

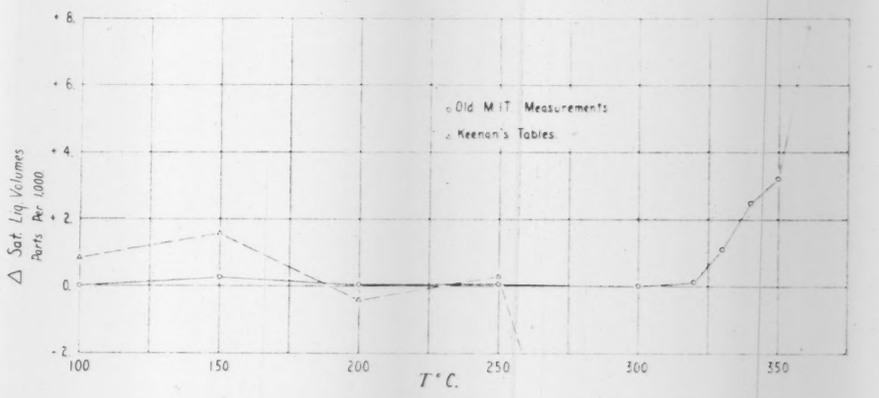


FIG. 3

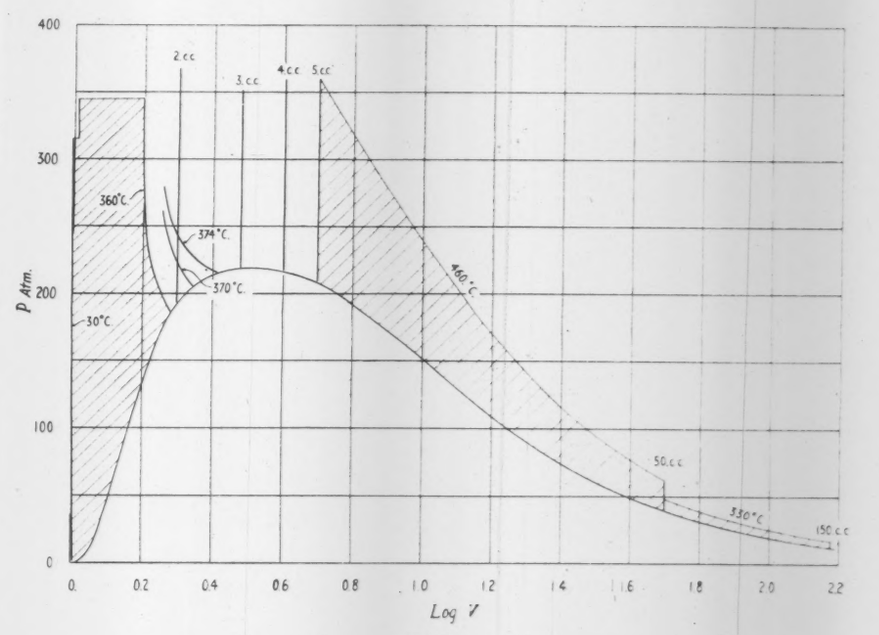


FIG. 4

sents the saturation conditions, and has been fixed by extrapolation of the measurements made on the liquid and the superheated vapor.

Progress of Work at the U. S. Bureau of Standards[6]

BY NATHAN S. OSBORNE[7]

EXPERIMENTAL work on saturated steam in the range of higher pressures has been actively continued, using the new calorimetric equipment[8] specially developed for this extension of the range.

Preliminary measurements of the heat of the liquid in the range of the previous measurements were carried out to test whether the new calorimeter, lacking the means of positive circulation of the water, would reproduce the earlier results.[9] It was found that during the period of heating, the surface distribution of temperature on the unstirred calorimeter was so irregular that the five thermoelements provided were insufficient in number to account for the heat leak and yield the precision of measurement previously attained. This was remedied by installing seven additional thermoelements. New experiments indicate that this fault has been overcome.

Measurements of the Gamma[10] or specific vaporization factor, $Lv'/(v' - v)$, indicated that this quantity, essential to the determination of the heat of vaporization, could be accurately determined. Measurements of the Beta[11] or correction factor, $Lv/(v' - v)$, indicated the need for an additional thermoelement on the liquid-outflow tube to account more accurately for the temperature of the outflowing liquid. This addition and several other changes in the thermoelements have been made as the result of these preliminary calorimetric-test experiments.

The usual difficulty was at first experienced in getting the calorimeter with its connections absolutely free from leakage at the high temperatures and pressures, but this has apparently been satisfactorily overcome.

It now remains to complete a systematic group of calorimetric measurements to determine the enthalpy of the saturated liquid and vapor, and there is good reason to expect this may proceed successfully. The equipment has been operated up to the critical temperature and pressure of water, and there is prospect that the method may yield reliable calorimetric results beyond the 2500-lb limit which was set as the goal of this experimental attempt. It is expected that the program will be completed within the coming year.

While the tests and adjustments of the calorimetric apparatus were in progress, opportunity was found to make some measurements of the vapor pressure of water. Provision for these measurements had been originally included as incidental to the calorimetry and to provide a check upon vapor-pressure data. These arrangements proved very satisfactory for the rapid and reliable measurement of vapor pressure, which is of course the simplest to measure of all the thermodynamic properties of a fluid. The preliminary measurements disclosed lack of complete agreement with the previously published data on this property, but showed very satisfactory agreement with the privately communicated results of a recent series of measurements, as yet unpublished, by Messrs. A. Egerton and G. S. Callendar in England.

The vapor-pressure relation is of fundamental importance in the formulation of steam tables, and especially in the correlation of calorimetric data with other thermodynamic properties by use of the derivative dp/dt in the Clapeyron equation. It is evident that adequate knowledge of this relation as a systematic formulation is indispensable as a basis for establishing the saturation limit, which is virtually the backbone of a complete formulation of the behavior of steam. In view of the previous incomplete accord in the values of this essential property, it was therefore decided to utilize fully this opportunity and proceed with a further verification of this relation.

The description of this work may be found in the complete report[12] presented to the Society and soon to be published under the co-authorship of Messrs. Stimson, Fiock, and Ginnings, and need not be reviewed here. There are a few points which may be mentioned regarding the formulation of the results, the agreement with other observers, and the possible relation of the new pressure data to future revision of steam tables.

Before these results were available, a study was begun of types of empirical equations suitable for representing the vapor-pressure relation. Attempts to formulate existing data by this means fell short of complete success, although indicating strongly that the fault lay with the consistency of the data rather than with the methods of formulation. As the new experimental results were obtained and tested by this method of formulation, greater improvement was found in the agreement between experiment and formula. The final formulation of the complete series of new experimental results seems to warrant the conclusion that the vapor-pressure relation is capable of expression by means of formulas suitable for the calculation of any pressure or of its derivative in the range 100 C to 374 C. The order of agreement alone between formulation and observation does not establish the reliability of the results, because systematic errors of measurement would not appear in the comparison. However, all apparent sources of error have been considered in making the estimate of accuracy, and it is believed that the figure, 3 parts in 10,000, given for the reliability index, is reasonably conservative.

Comparison with the recent results of Messrs. Egerton and Callendar, mentioned above, which are expected soon to be published,[13] and also with the recent results obtained at the Massachusetts Institute of Technology by Messrs. Keyes and Smith, confidentially communicated, indicates that these recent independent measurements are, in general, mutually confirmatory. Comparison with the results of Holborn and

[6] Publication approved by the Acting Director of the Bureau of Standards of the U. S. Department of Commerce.

[7] Physicist, U. S. Bureau of Standards, Washington, D. C.

[8] MECHANICAL ENGINEERING, vol. 54, no. 2, p. 118, Feb., 1932.

[9] Trans. A.S.M.E. (1930), paper FSP-52-28, p. 191.

[10] Ibid.

[11] Ibid.

[12] This report appears in the Bureau of Standards *Journal of Research*, vol. 10, February, 1933 (Research paper 523). Several typographical errors may be noted in the separate preprint of the report as released for publication Dec. 5, 1932, by the A.S.M.E. These are as follows:

P. 6, 4th paragraph: 0.001 F should read 0.001 C.

P. 13, Table 3, column 4: at 300 C, 8491.1 should read 8591.1.

P. 15, Table 5, column 3: at 541 F, 8.052 should read 8.053.

P. 15, Table 5, column 7: at 705 F, insert 21.254.

[13] Since the presentation of this report Egerton and Callendar's paper "On the Saturation Pressures of Steam (170 C to 374 C) has been received (published Dec. 1, 1932, in Phil. Trans. Soc. Lond., series A, vol. 231, paper A698). In this paper (p. 204) a series of later measurements is reported in the range 100 to 300 lb per sq in. These measurements show greater consistency than the earlier ones, and agree even better with the Bureau of Standards results.

Henning,[14] reduced to the present International Temperature Scale, shows likewise only minor discordance. The agreement with the results of Holborn and Baumann[15] is, however, not quite so satisfactory, and the somewhat larger difference in general trend may mean that the technique of these measurements in the range 200 C to 374 C, made over twenty years ago, may have admitted a larger tolerance of experimental error than is now necessary.

The tables given in the report have been prepared for use as practical working tables and for the intercomparison of the pressure data in current steam tables. They are expressed in terms of four different pressure units, which may merit a few words of explanation

The "standard atmosphere" is the standard international unit which has been used as a basis of reduction of the measure-

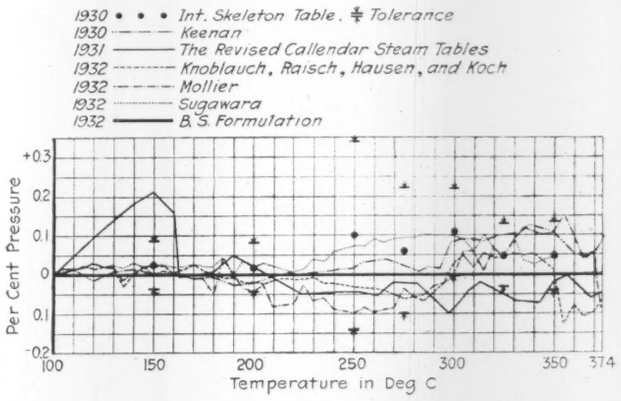


FIG. 5 DEVIATION CHART—CURRENT STEAM TABLES (SATURATION PRESSURE OF STEAM)

ments. This unit, as defined, is independent of the local force of gravity.

The "centibar" is a decimal subdivision of an internationally recognized unit of pressure, being derived directly from the fundamental units of length, mass, and time, independently of the properties of matter and of the intensity of gravity. The product of centibars by cubic decimeters gives watt-seconds of work, requiring no conversion factor as the mechanical equivalent of heat. It is therefore the natural unit for thermodynamic calculations in the metric system, and might very appropriately be introduced to engineering students to acquaint them with their independence of a numerical constant venerated as the mechanical equivalent of heat.

The "kilogram per square centimeter" needs no comment beyond the fact that it is indefinite until the intensity of gravity is specified, and that, for want of a name of its own, it is frequently confused with the standard atmosphere, having roughly the same value.

The "pound per square inch" also involves the force of gravity, and this occasions annoying confusion when compilers of steam tables employ the local value of gravity, as in the case of the Revised Callendar Steam Tables of 1931.

This group of vapor-pressure tables, based on a single formulation, furnishes a convenient reference medium for the intercomparison of tables of steam-pressure data, since it obviates the necessity of converting the values all to the same unit of pressure. Values of the derivative dp/dt, calculated from the formulation and tabulated coordinately, furnish consistent values of this correlating factor. The order of agreement of the values of saturation pressure of steam as tabulated in several recent steam tables is shown graphically in Fig. 5 by reference to this formulation.

It is possible that when the results of the recent experimental work are all available, improved accord in this fundamental element of steam tables will be attainable.

Several imperfections in the International Skeleton Table of saturation steam pressures which are exhibited in this comparison chart should be susceptible of remedy in future revision. For instance, no way is provided to fix the tolerance otherwhere than at the widely separated fixed points. A table might accord at these points and meander widely elsewhere. Or, in case of a table compiled in fahrenheit degrees, the tabulated points may lie between the fixed points and therefore be incapable of a conclusive check.

It may be thought that this case would naturally be covered by interpolation. This, however, would evidently be unreliable in a table where the values are so far rounded as to admit an uncertainty even greater than the tolerance itself Such cases are actually to be found in the group of tables compared.

An obvious way to avoid this fault would be to effect a greater degree of continuity in the master table, either by adopting sufficient fixed points, or perhaps even better by adopting a formula for the relation. The latter would have the additional advantage of supplying consistent values of the derivative dp/dt, which is the correlating factor at the saturation limit.

It is apparent from the deviation chart that the definitive values of the International Skeleton Table of saturation pressures depart considerably both from the experimental data and from the general trend of recent steam tables. It is also apparent that the present tolerances are not only inconsistent in relative size but allow a wider latitude than is either desirable or now necessary.

The adjustment of steam tables toward uniformity should proceed in a proper sequence. Standardization of the elementary relation between the two primary variables, temperature and pressure, is obviously a first step. Consistency and accord depend in part on the veracity of evaluation of this characteristic relation, and an erroneous evaluation obstructs the improvement of steam tables in other respects It is therefore important that the revision of this elementary portion of the International Steam Table should receive early consideration.

[A paper on "Recent Steam Research in Europe," by Prof. J. H. Keenan, also presented at the Steam Tables Session of the A.S.M.E. Annual Meeting, will appear in the March issue of MECHANICAL ENGINEERING.—EDITOR.]

In a lecture before the Institution of Mechanical Engineers on November 4 last, Lord Rutherford pointed out that while the swiftest alpha particles have a speed of about 10,000 miles per second, the engineer can hardly hope in his work to reach speeds of more than two miles per second, which is about the limiting speed of a rotating disk made of steel. This is of the same order of magnitude as the average speed of molecules of gases under ordinary conditions. The average velocity of agitation of the molecules of oxygen gas at normal temperature is about 1/4 mile per second, and of hydrogen molecules, about 1 mile per second. The muzzle velocity of "Big Bertha," the gun with which Paris was bombarded from a range of some 80 miles, did not exceed one mile per second. The great Siberian meteorite which fell in 1908 and caused widespread devastation is estimated to have weighed 100 tons and to have had a striking velocity of 40 to 50 miles per second.

[14] *Ann. der Physik*, vol. 26 (1908), p. 834.
[15] *Ann. der Physik*, vol. 31 (1910), p. 945.

MECHANICAL ENGINEERING

Vol. 55 FEBRUARY, 1933 No. 2

GEORGE A. STETSON, *Editor*

Recent Social Trends

NO ONE can read the summary of the recently published survey on "Recent Social Trends" without being impressed by the fact that whatever imagined isolation engineers and technologists may have had, has been permanently broken down. Throughout the entire summary science, invention, technology, and engineering appear as dominant social factors that have powerful effects in shaping the nation's development. To look upon our modern society from the vantage point of this comprehensive study is to see in clear perspective numerous important interrelationships of apparently unrelated actions which provide the pattern of our complex life and determine the misery or happiness that attends it.

While the findings of President Hoover's committee provide a more extensive and more comprehensive statement of the condition of modern society than is easily accessible elsewhere, and while it affords a much-needed coordination of the observations of numerous competent specialists, thoughtful persons have always been aware of the existence and importance of the major directive forces to which attention is properly called. The report will give added emphasis to the necessity for an intelligent handling of social problems, and should awaken a sense of understanding in the minds of the complacent and the impatient alike. For until people in general attain a sympathetic understanding of the problem, its solution will remain unattainable. The inertia of ignorance and indifference is an even greater handicap to social progress than it is to scientific progress. Individual diligence may add tremendously to the logical development of science; but society is made up of groups of individuals, whose wills, desires, and actions lack unity of purpose and direction. Whatever progress is made is in the nature of a persistent drift of unregulated cross-purposes, and is seldom accelerated by common purpose and direction. The drift itself, however, and the major currents within it, are sensitive to the disturbing effects of innumerable individual and collective actions.

A USEFUL REPORT

No more propitious time for the publication of the report could have been chosen than the present. The nation has accustomed itself to the facing of unpleasant facts. It has ceased to have faith in or patience with platitudes and honeyed philosophies. Had the mad pace of 1929, in which year the Committee began its work, continued, we might have heard a fatuous benediction pronounced on "new era" prosperity, or, if a report of the present complexion had resulted, we might have howled it down and disregarded it. As it is, with men willing to concede the seriousness of our plight and eager to seize upon constructive devices that will bring relief and stability to our economic and social structure, there is excellent opportunity that a maximum of consideration will be given to it.

And so, regardless of whether the President had an open mind as to what the ultimate findings might be, and desired only to learn the truth as earnest and competent men might uncover it for him, or, as some are unkind enough to suggest, he had no idea what serious flaws in our culture it would disclose, the report is likely to become one of the most important documents of the depression, and to redound greatly to the credit of our chief executive. He has provided a useful means of seeing "where social stresses are occurring and where major efforts should be undertaken to deal with them constructively." It is to be hoped that his successor and those who counsel him and administer with him will make wise use of the findings.

NO MORATORIUM ON RESEARCH

Evidence of the sanity of those who wrote the report is to be found in the attitude they take with respect to technological progress. They demand no moratorium on research in physical science and invention. On the contrary, they hold that "social invention has to be stimulated to keep pace with mechanical invention," and they ask the question, so frequently asked and discussed in MECHANICAL ENGINEERING, "How can society improve its economic organization so as to make full use of the possibilities held out by the march of science, invention, and economic skill, without victimizing many of its workers, and without incurring such general disasters as the depression of 1930–1932?"

It was such a question that prompted Mr. Charles Piez, early in 1930, to say in MECHANICAL ENGINEERING:

> Technologically the future is secure. We have learned the art of applying science to useful ends. What we still lack is that greater wisdom to wipe out the plague spots, to bring about orderliness in the control of the vast forces we unloose so that we may have progress without the waste in human and other material which has marred many of our past efforts. The problems involved are largely outside of engineering in its narrow sense—they are humanitarian, economic, and political problems.

ENGINEERS AND SOCIAL FORCES

Except in times of great national peril, as in war, or when a dictatorship establishes a common goal, nothing more definite than "life, liberty, and the pursuit of happiness" exists as a national objective. This, translated into terms of individual desires and ambitions, leads to the inevitable conflict between what is advantageous to the individual and what is best for society. By a judicious application of the principle of enlightened self-interest, civilized men attain a semblance of serving the common cause by serving them-

selves. As standards of living rise, individual opportunity and security increase. The constructive elements of a rise in the material standard of living, as has frequently been brought out, are the increased use of cheap and universally available power, the development of science and invention, and the will to do what is necessary to make these effective. Now engineers are quite definitely interested in all three of these factors. They are the acknowledged creators and operators of machinery for producing, distributing, and utilizing power; they are traditionally concerned with the development of science and invention in usable forms; and they have made notable contributions to the third factor in the theory and practice of management. They possess, therefore, exceptional advantages when it comes to making constructive attempts to raise the standard of living. If they can obtain the collateral knowledge of human affairs necessary for an integration of human skill and understanding into human progress, and the wisdom to apply this knowledge, they can do more than accelerate social change—it is possible that they may assist in consciously directing it. But it would be presumptuous for them to look upon themselves as the sole saviors of society.

ENGINEERS AND PLANNING

And this leads to planning that seems so inevitable a necessity to the eminent sociologists that wrote the report. Engineers live with plans; and perhaps one saving grace of engineering plans is their flexibility. The possibilities of change and extension are provided for in most of their plans. One of the great contributions that Gantt and other management engineers made was an easy means of charting the progress and essential control elements of a plan. The technique employed provides for the possibility of making frequent changes in the details or even the objectives of the plan to conform to a change in conditions. Budgets for the variety of purposes that engineers use them are in the category of flexible plans that are subject to periodical review and revision. Developments in the generation and distribution of power are seldom completed in a single stage. As subsequent stages are completed, the improvements in machinery and practice are utilized, and such changes in fundamental design as conditions warrant are very sensibly put into effect. Obsolescence and supersession are prudently allowed for, and the rates at which these are charged off vary with the known hazards of the industry in facing rapidly advancing technological progress. For engineers have learned that in spite of the fact that they can look ahead with some assurance of accurate prediction, they must have a wholesome respect for the hazards of extrapolation. In other words, the factor of probable change is generally allowed for and planning restricted as much as possible to the not-too-distant future. Indeed, so many logically conceived plans have gone awry because they were predicated on a fairly static condition in technology or customs, that long-time planning is notoriously precarious.

INVENTION A SOCIAL PROCESS

Such an adventure into the unknown as society is making by breaking away from the static economy of former times and embarking upon the dynamic economy of an industrial era, has its dangers and its hardships. There are those who find the impedimenta of such an adventure burdensome and of questionable value. The axe that clears the path through the jungle is heavy to carry and difficult to wield. Its keen edge works with suicidal effect in the hands of the incompetent and the unwary. They would have none of it, and view with apprehension a progress that must depend upon so crude and dangerous an instrument. Today that instrument is rapidly accelerating technological progress. It is reputed to be the fundamental cause of much of our social and economic unbalance, and the reasons for such an ill opinion are ably presented in the report on "Recent Social Trends." Yet we also find this report saying that in formulating the "general sketch of the complicated trends that are remolding American life, it finds its analytical description leading ever and again to a statement of problems which can be solved only by further scientific inventions and discoveries. . . . Discovery and invention are themselves social processes. . . ." and "nothing short of the combined intelligence of the nation can cope with the predicaments here mentioned." Future progess depends on this intelligent coordination.

NONE CAN TURN BACK

To this problem engineers will approach with courage and resolution, but with humility. They have neither superior wisdom nor judgment better fitted to the task than that of other men. If they have superior training and techniques in matters which directly affect the progress of material well-being, it is their duty to use them for the larger good and in the light of such broad considerations of the social order as the President's Committee has outlined. Through the development of researches now in progress they may some day have the opportunity of offering to their fellow-men such increments to the utilizable energy of the world that its widespread use will make our present consumption seem trifling by comparison. Their industry and inventiveness, under the guidance of enlightened direction, will provide new opportunities of surcease from crushing toil, and of leisure that is ennobling rather than degrading. Of the dangers that lie ahead, our present troubles are the shadow. But none can turn back, and only the weak would do so. We are probably better fitted to meet these dangers than any age ever was in facing its future. The reward is worthy of the effort. We can not see it clearly, and we are not able to foretell how the changes will come. The passing of every epoch in human history is a transition, rather than a finality, and of it may be sung the chorus ending of a 2500-year-old drama, often quoted in these pages:

> And the end men look for cometh not,
> And a path is there where no man thought.
> So hath it fallen here.

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICAL ENGINEERING (See Internal-Combustion Engineering: Experiments With the Supercharged Single-Cylinder Unit)

APPLIED MECHANICS

Investigation of the Boundary Layer Between Turbulent and Streamline Flow When the Rate of Main Flow Is Accelerated or Retarded

THIS article is of a mathematical character and cannot be abstracted in detail because of lack of space.

The purpose of the investigation described was to obtain, directly from the results of practical tests, the necessary data required for making the calculations, particulars concerning the distribution of velocities in the boundary layer, and also concerning the friction of the boundary surfaces, and to utilize these data for carrying out the calculations of the turbulent boundary layer. The difficulties encountered by this method are concentrated in the following points. First of all, it is necessary to determine how the conditions of flow in a cross-section can be approximately characterized, so that it may be possible to apply the conditions determined in a certain cross-section of the measured flow to a certain cross-section of the flow that has to be calculated. Based on this, the distribution of velocities in the boundary layer has next to be determined, after which a law for the boundary-surface friction can be chosen.

The author defines the velocity profile as a non-dimensional diagram of the velocity in the boundary layer, or of the coordinates, of which one is the ratio of average value (with regard to time) of the turbulent impulses of the velocity in the boundary layer in the direction of the curvilinear coordinate along the surface of the main current, to the velocity for potential current without friction, and the length characteristic of the boundary layer is the other. The magnitudes defining the state of a fluid are set forth.

From a strictly hydrodynamical point of view, the occurrence of the same form of flow with another kind of main flow is impossible, since the flow in the boundary layer at a certain point is determined by the conditions before and after that point. Under certain conditions, however, the occurrence of approximately the same conditions of flow may be expected. It is only a question of finding a characteristic as suitable as possible for the occurrence of approximately the same conditions of flow in separate cross-sections, and then carrying out tests to see how good the agreement is and whether it is sufficient for the demands of the calculation. This characteristic figures in the calculation as a parametric function, formed from the calculated magnitudes of a cross-section.

The author proceeds next to the coordination of the profile forms. The velocity profile is one of the forms showing the state of the flow in cross-section of a boundary layer. Having previously obtained a series of results of measurements, it is possible to determine the profile forms of the individual cross-sections and also the corresponding value of the parameter function. With the limits set for the approximate calculation given by the author, he concludes that in a boundary-layer flow which has to be calculated, the same profile form occurs as soon as the calculation gives the same value for the parameter function in the cross-section under consideration. The mathematical method of derivation of the distribution of the velocities by means of the profile forms is given in the original article.

Besides the profile form, it is also necessary to determine the wall friction by experiment.

Apart from the influence of roughness and curvature of the walls—factors difficult to grasp—the way in which the friction of the walls depends on the acceleration or retardation of the main flow was, until recently, quite unknown. According to what has been published, Professor Stodola was the first to endeavor to clear up this question. Here the treatment is confined to cases where the walls are smooth and their curvature negligible.

The author derives an expression for a function of the parameter involved, and tests discussed elsewhere in the article confirm the truth of the law which he derives. Next, by means of a somewhat involved mathematical calculation, he derives an equation of the impulses, which, however, holds good only for the practical law of resistance chosen here. In order to simplify the impulse equation he next adopts the supposition of a single parameter. This simplifies the mathematics, but necessitates the calculation of the possibility of error arising from this approximation. Incidentally these experiments show that the experimentally obtained values of the function which the author derives for accelerated and for retarded main flow may each be represented to a very close degree of approximation by a straight line, which simplifies the previously-referred-to equation of the impulses. The solution of the differential equation of the boundary layer comes next, and this is followed by the description of the experimental part.

From curves (Fig. 12) and a table in the original article, it is found that in the whole zone measured and independent of the acceleration, the friction of the wall for the boundary layers on the cylindrical tube and also at the core used in the experiment is represented fairly well by an equation (No. 11 in the original article) with the average value of product of resistance coefficient by a certain tangent defined in the original article by Equation 5 as a certain average value given in the same article.

According to measurements made in pipes, and according to Kármán's considerations on the dimensions, the resistance coefficient ζ, for a flow at *constant* velocity, is found from a simple calculation to be $\zeta = 0.01185$, which is in agreement with the value ζ for constant and accelerated flow according to recent experiments.

The assumptions and formulas for the calculation of the boundary layer are briefly summarized.

The fundamental bases of the calculation hold for "smooth surfaces," a condition which is to a large extent fulfilled by most of the surfaces met with in practice. With regard to the Reynolds criterion, this holds within the practically important region $Ul/\nu = 200$ to 4000. The fundamental bases of the calculation are affected by the limitations required for the boundary-layer theory; thus, the curvature of the walls in the direction of the flow must be negligible. Further, the form of the

boundary layer may not have any influence on the main flow; for example, the turbulent zones of two opposite surfaces of the walls may not overlap. Also the region beyond any break in continuity of the boundary layer is excluded from the mathematical treatment.

For a given problem the main flow must be determined as a function of x according to the rules and methods of the potential theory (in simple cases, according to the equation of continuity and Bernoulli's law). U and U' are thus determined for the actual boundary-layer calculation. The remainder of the article is not suitable for abstracting. (Bu. in *Sulzer Technical Review*, no. 3, 1932, pp. 4–14, *mA*)

FUELS AND FIRING

The Relative Fuel Economy of Electricity, Gas, Oil, and Solid Fuel as Heating Agents

THIS paper is an effort to explain the reason why and the conditions in which electrical power can be used competitively for the heating of buildings, in spite of the fact that the cost of the crude heat is several times greater than that of any other heating medium. It deals exclusively with the cost of the fuel and the labor inevitably incurred in handling it, and not with questions of capital cost and matters of an allied nature.

It details the causes of loss of heat inevitably incurred in the use of any other form of fuel, estimates their respective amounts, and traces the stages by which the heat generated at a central boiler house is frittered away as it travels to the rooms where it is required.

The principal features which enable electrical power when suitably installed to compete with other fuels are its 100 per cent technical efficiency, its instantaneous control, and its very low time lag and absorption. It is shown that, owing mainly to these features, an amount of heat fully equivalent to the energy of the electrical current used can be delivered at the exact time only when it is required, thereby avoiding the waste caused essentially by the lack of accurate timing inevitably associated with all systems in which heat is generated in and distributed from a central boiler, whether or not this is electrically heated. In this sense electricity, locally applied, is the only means by which an overall "efficiency" of 100 per cent can be rationally claimed for an entire installation—in the sense that the amount of electrical energy used is equal to the bare minimum of the heat physically necessary to secure the desired result.

The overall efficiency of the heating process by other media is determined as the continuous product of numerous detailed efficiencies (corresponding to the various stages of loss), each of which is so defined that their continuous product may be equal to a final "overall efficiency" representing the ultimate ratio between the heat physically necessary for securing the desired result and that in the fuel purchased.

Representative maximum, medium, and minimum values are in all cases given of each of these factors where they are liable to wide variation, and the tables containing them are drawn up in such a form that they can readily be corrected for any variation in these assumed values.

A close comparison is made between the features of electricity and gas (herein called "the mobile fuels") as heating agents; also between the operating characteristics of the "portable fuels"—oil and coke. The labor involved in handling the fuel in each case is considered in detail.

A sharp distinction is drawn between the relative costs in the respective cases of continuous and intermittent heating. It is in the latter that the economy of electric heating shows to greatest advantage; the reasons for this are given.

Explanations are advanced of the reasons why instantaneous control, such as is only obtainable by electricity, is of great importance in restricting the unnecessary use of heat and at the same time in applying an adequate amount for maintaining comfort conditions during all times of actual occupation, and only during those times.

Numerical tables and diagrams are given showing the progressive loss of heat in the various stages through which the heat passes, and explanations are given of the details of the calculations of the heat quantities really necessary for maintaining the required temperatures, as well as of the proportions inevitably dissipated in the process of delivering heat from a central point to the rooms. The ratio between these is called the "occupation efficiency," the incidence of which on the calculated result is fully explained. Finally a table is given in which, assuming fixed prices for the crude heat, average medium values for the various factors involved and theoretical perfection of the heating result for an assumed period, the relative annual costs of heating 1000 cu ft of average space by the various media are calculated.

It is emphasized that all the factors on which these costs depend are essentially very variable, and that no such table of relative costs can conceivably be absolute apart from the factors involved.

The original article also contains numerous tables, one of which gives the relative costs of fuel and labor in British units per annum per 1000 cu ft of standard building space (2000 Btu per hr calculated heat loss) based on prices given in the article. (A. H. Barker in a paper read Dec. 1, 1932, before the *Institution of Electrical Engineers*, London; abstracted from preprint, *c*)

The Marketing of Pulverized Coal in Great Britain

THIS paper deals with British conditions only. In England all pulverized-fuel plants which have hitherto been installed or proposed have included the necessary grinding machinery, and when the capital cost for such installations is compared with that required for fuel-oil plants, the latter show up to advantage. On the other hand, if arrangements are made for coal to be delivered to the consumer already prepared in powdered form, then the cost of the equipment for the storage and burning of pulverized fuel, although still higher than that for oil firing, compares very much more favorably.

Fig. 1 shows the approximate all-in capital cost of converting a battery of Lancashire boilers from hand firing to pulverized-fuel firing, with and without the grinding machinery, and also to oil firing. This represents the average capital outlay for the complete installation, including all equipment, bunkers, erection, buildings, and foundations. Actual costs will vary, of course, with different site conditions; but the curves shown are believed to be of sufficient accuracy to give a general comparison of the cost of installing either of the three systems on a similar type of boiler plant.

The case of oil versus coal must not, however, be prejudged on the evidence of the curves alone.

The author states that for some time past organizations have been developed on a commercial basis in Germany and America for the manufacture of pulverized fuel in bulk and for its transport in a powdered state to consumers. An appendix to the original paper not printed in the abstract tells of the visit of two representatives of *The Steam Engineer* who spent two months in Germany studying the progress made in the transport and marketing of powdered coal and coke. From this it would appear that the earlier difficulties experienced from the

tendency of powdered fuel to pack and solidify during transport have now been effectively overcome, and that there are several designs of tank wagons and methods of loading and unloading now in commercial use.

Special tank wagons are necessary for the conveyance of powdered fuel, and the transport charges are therefore higher than those for the transportation of raw coal. A certain proportion of this extra cost can, however, be discounted as the pulverized coal is transported dry, whereas raw coal, and especially washed coal, frequently contains a high percentage of moisture. In Germany it has been found uneconomical to transport their brown coal in its raw state, owing to its high moisture content, and the majority of this fuel, not briquetted, is now dried and conveyed in pulverized form to consumers.

The tanks, both for transport and storage, must be of airtight construction to prevent the escape of powdered fuel and the entry of moisture.

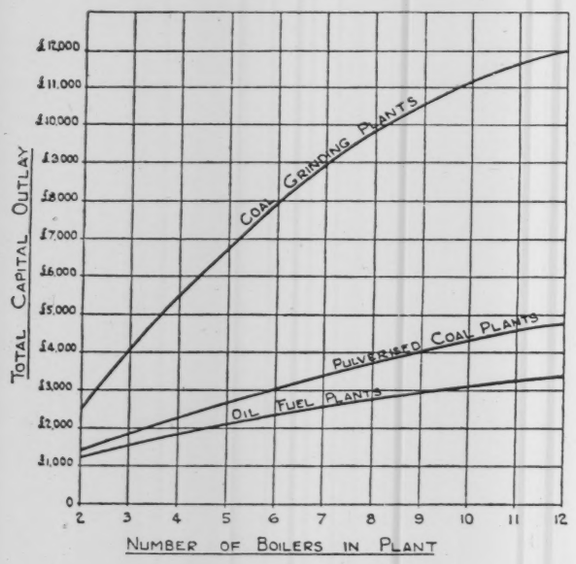


FIG. 1 COST OF CONVERTING A BATTERY OF LANCASHIRE BOILERS FROM HAND FIRING TO PULVERIZED-FUEL FIRING

The methods of loading and unloading at present in use may be divided into three categories. The first comprises detachable containers where the tanks containing the powdered fuel are themselves lifted off the truck or railroad car and placed on top of the consumer's main storage bunker into which the powdered fuel is then emptied. These tanks are designed so that the action of lifting from the car breaks up the solidified fuel and when lowered on to the consumer's storage bunker, doors in the base of the container open automatically, allowing the powdered fuel to flow into the bunker.

In the tipping tank wagons an opening in the rear of the tank wagon is connected to a manhole in the top of the consumer's bunker by a canvas chute. The tank is then tilted by raising the forward end, and a mechanical agitator inside the container assists the coal dust to flow through the canvas chute into the consumer's bunker.

In addition to this there are several systems of unloading by compressed air.

The latest design of pulverized-fuel tank wagon embodies a combination of mechanical and pneumatic means for loading and unloading which gives several advantages over other types. Although this design of wagon has not yet been constructed and put into service, it is estimated that it will be capable of being loaded or emptied at the rate of one ton per minute, which will be a marked advance on any existing type.

In Germany the majority of powdered fuel is delivered by rail transport, owing to the geographical positions of the sources of supply in relation to consumers. The rail cars are usually allowed to remain free of charge for 24 hr at the consumers' works to permit of unloading as and when convenient, but a fairly heavy charge is made for demurrage over 24 hr. The development of the marketing of powdered fuel in Germany appears to have clearly established the fact that the transport of this product is now a perfectly practicable commercial proposition.

The cost of transporting pulverized coal is compared with that of oil fuel. This part is of no interest to Americans. (Commander H. D. Tollemache in a paper before the annual meeting of the Institute of Fuels, abstracted through *The Steam Engineer*, vol. 2, no. 3, Dec., 1932, pp. 131–133, 2 figs., *d*)

HYDRAULICS

Experiments on a Right-Angled Triangular Notch With Incomplete Contractions

THE authors have experimentally investigated what increment is caused in the coefficient of discharge for a triangular notch when the width of the channel of approach is not ample. The experiment was carried out under the instructions of Prof. I. Oki who wrote an article entitled "Some Considerations of a Triangular Notch With Incomplete Contractions" (*Journal of the Society of Mechanical Engineers*, Japan, Vol. 35, No. 180, April, 1932, p. 280).

The apparatus which the authors used consisted of a thin-edged right-angled triangular notch fitted at the end of a channel of approach 30 cm wide in the first series of experiments and 20 cm wide in the second series. The channel was 55 cm deep and 552 cm long. The volume of water passed over the notch was determined by means of calibrated tanks and the head was measured by a hook gage.

The results of the first series of experiments are shown in Fig. 7 and the second series in Fig. 8 in the report (written in Japanese). Throughout the experiments the authors noticed that when the head was very low the water clung to the edges of the notch and the discharge was greatly increased. If the downstream side of the notch plate be coated with paraffin wax the stream contracts very finely, so that the coefficient of discharge becomes very small. For these two cases in each series of experiments the authors determined that the increment of the discharge coefficient was due to the incompleteness of the side contractions, and concluded that the expression for correction of the discharge coefficient due to the incomplete contractions proposed by Prof. I. Oki was nearly true within the limits of their experiments. (Sigemasa Yosino and Tiharu Yamada in a paper published in Japanese in the *Journal of the Society of Mechanical Engineers, Japan*, vol. 35, no. 187, Nov., 1932, pp. 1112–115, 9 figs.; the foregoing summarizes the English abstract on pp. S30–S31 of the original publication, *e*)

INTERNAL-COMBUSTION ENGINEERING

Experiments With the Supercharged Single-Cylinder Unit

THIS paper deals with experiments carried out in the Engineering Laboratory of the University of Manchester on two different types of aero-engine cylinder. The cylinders were mounted on a R.A.E. Universal test bed, and supplied

with compressed air from a separately driven Reavell compressor, the air being passed through an intercooler before being supplied to the carburetor.

The object of the experiments was to examine the effects of increased induction pressure, at a range of compression ratios, on the behavior of the cylinders in regard to such variables as power output, heat losses, and fuel consumption.

The cylinders used for the tests were (1) a Napier E. 77 type, two-valve, all-steel cylinder, and (2) a Rolls-Royce F. type, four-valve cylinder, having a steel liner and aluminum-alloy head.

A set of trials was first carried out using the Napier cylinder at compression ratios of 4.5 to 1, 4.0 to 1, and 3.5 to 1. "Straight" Shell No. 1 gasoline was used, the engine speed being 1600 rpm throughout.

During each trial measurements were made of the induction pressure, the power output, the gasoline and air consumption, and the heat flow to cylinder jackets and to exhaust. With the Napier cylinder, separate trials were run at each compression ratio, when the maximum cylinder pressure was recorded at a range of compression ratios, using an Okill pressure indicator.

On completion of the above tests, the Rolls-Royce cylinder was mounted on the test bed and a second set of trials was carried out at an engine speed of 1600 rpm. Except for one series of trials with gasoline at 4.0 to 1 compression ratio, the fuel used with the Rolls-Royce cylinder was in all cases pure benzol. With this fuel a series of trials was carried out at each of the following compression ratios, viz., 4.0, 5.0, 5.5, 6.0, 6.5, and 7.0 to 1.

The results indicate that:

1 At all compression ratios the permissible mixture range is narrowed by increase of induction pressure.

2 As the compression ratio is raised, at any given induction pressure, the working mixture range is extended.

3 If the ignition timing remains unaltered, the complete range of permissible mixture strengths moves progressively toward the weak side as the induction pressure is increased. By retarding the ignition, the mixture range is moved back toward its position at normal induction pressure.

4 Although the mixture strengths for maximum power and maximum efficiency alter in conformity with the movement of the complete range, the respective mixture strengths giving maximum heat flow to the jackets and to exhaust remain unaltered under all conditions.

The alterations in the permissible mixture range referred to above are more pronounced in the results from the Rolls-Royce cylinder under all conditions than in those from the Napier, in addition to which the available mixture range is in all cases wider with the latter cylinder.

The volumetric efficiency, taken as the ratio (weight of air actually consumed) ÷ (volume swept by the piston × density of air at induction temperature and pressure), increases considerably as the induction pressure is raised, the rate of increase becoming progressively less as the supercharge is increased. At a given induction pressure the rate of increase in volumetric efficiency becomes less as the compression ratio is raised. Thus, while at normal induction pressure the volumetric efficiency is approximately the same at all compression ratios, under supercharged conditions it is reduced by an increase in compression ratio.

The rise in volumetric efficiency under supercharged conditions appears to be due to the fact that, under these conditions, not only has the swept volume to be filled with air, but in addition a further supply is required to fill up the clearance space, since at the commencement of the charging stroke this space will contain residuals at approximately atmospheric pressure.

At a given compression ratio, the ratio (ihp) ÷ (weight of charge per minute) is constant and independent of the induction pressure, provided conditions are not such as to require a seriously retarded ignition timing. The value of the ratio is moreover the same for both cylinders at the same compression ratio, and remains unchanged whether the fuel is gasoline or benzol.

With constant induction temperature the imep increases at a constant rate as the induction pressure is increased. For the Rolls-Royce cylinder, at the maximum-power mixture strength, the value of the ratio (percentage increase in imep) ÷ (percentage increase in absolute induction pressure) is approximately 1.155 at all compression ratios.

For the Rolls-Royce cylinder, irrespective of compression ratio, the mean value of the ratio (percentage increase in bmep) ÷ (percentage increase in absolute induction pressure), at maximum-power mixture strength, is approximately 1.49 with the supercharger separately driven, and approximately 1.27 when allowance is made for the supercharger being driven from the engine at 65 per cent adiabatic efficiency, though in the latter case the ratio tends to decrease slightly as the induction pressure is increased.

For the Napier cylinder, using gasoline, the above ratio (supercharger separately driven) increases slightly as the compression ratio is reduced, and decreases at each compression ratio as the induction pressure is raised, the approximate mean values being 1.53 at 4.5-to-1, 1.58 at 4.0-to-1, and 1.63 at 3.5-to-1 compression ratio.

At a given compression ratio the indicated thermal efficiency remains approximately constant at all induction pressures, provided that the ignition does not require to be retarded seriously, and that, at the lowest compression ratios, the induction pressure is sufficient to insure an adequate degree of turbulence.

Subject to the above conditions, the ratio of the indicated thermal efficiency to the theoretical air-cycle efficiency is constant at all compression ratios, the value of the ratio being approximately 0.617 for the Rolls-Royce cylinder at the 98 per cent full-power mixture, using benzol as fuel.

With the mixture strength adjusted to give 98 per cent full power and the supercharger separately driven, the gain in brake thermal efficiency with increase in compression ratio is appreciably greater at normal induction pressures than is indicated by the expression giving the standard air-cycle efficiency. As the induction pressure is raised the ratio (observed efficiency) ÷ (air-cycle efficiency) tends to increase more slowly with increase of compression ratio, until, when conditions are such as to demand an appreciably retarded ignition timing, the ratio reaches a maximum value and thereafter diminishes slightly.

At each compression ratio, with the supercharger separately driven, the fuel consumption per brake horsepower (at 98 per cent full power) decreases as the induction pressure is increased, the rate of decrease being greatest at the commencement of the range and becoming less as the supercharge is increased. At a given induction pressure the rate of decrease becomes less as the compression ratio is raised. At each compression ratio a point is reached when further increase of induction pressure no longer gives a decrease in specific consumption, this point coinciding with the point at which conditions become such as to demand an appreciably retarded ignition timing. At the point referred to, for the Rolls-Royce cylinder, the decrease in specific consumption, expressed as a percentage of the value at normal induction pressure, is approximately 26 per cent at

4.0-to-1, 16 per cent at 5.0-to-1, 9 per cent at 6.0-to-1, and 5 per cent at 7.0-to-1 compression ratio. When allowance is made for the supercharger being driven by the engine (at 65 per cent adiabatic efficiency), the above percentages become approximately 16 per cent at 4.0-to-1, 8 per cent at 5.0-to-1, 4.0 per cent at 6.0-to-1, and 1 per cent at 7.0-to-1 compression ratio. (G. F. Mucklow in *British Air Ministry Reports and Memoranda* no. 1460, 57 pp. and 43 diagrams, Nov., 1931, abstracted from official summary, *e*)

Recent British Marine Engines

AT THE Marine Motor Show in London the following exhibits, among others, were shown. The Brooke Marine Motors Co. showed a single-cylinder two-stroke engine with a designed output of 2 to 5 hp. It is mounted on a bracket-like bedplate which allows the unit to be screwed down by only four bolts. When the boat is laid up the unit can be easily removed and used for belt driving or generator work. The clutch and thrust block are in one piece with the motor, and the propeller shaft may be run in a stern gland only, no stern tube being necessary. It is intended to burn gasoline.

The Ailsa Craig Motor Co. showed several engines working on the Acro airless-injection principle and utilizing heavy fuel oils. They also showed a twin-cylinder opposed-piston gasoline engine designed to fit under a thwart or cockpit floor. It develops 4 to 6 hp at 1000 to 3000 rpm, and with reversing gear weighs only 140 lb.

The Birmal Tri-Star marine gasoline engine has three cylinders with inclined side valves which are radially disposed around a vertical single-throw crankshaft fitted with slipper-type big-end bearings. The drive from the crankshaft is taken through spiral bevel gears which run free on a layshaft, the forward, neutral, and reverse drives being obtained by two sets of coil-spring clutches, while the propeller thrust is taken up by a double thrust bearing. This arrangement makes it possible to incorporate a reduction gear of either 1.7 to 1 or 2 to 1 with a 100 per cent reverse.

The gear box made by Vosper & Co., Ltd., and shown in Fig. 2 has several interesting features, among them being the fact that it can be assembled with either two or three wheels, consequently allowing the direction of rotation on the propeller shaft to be changed at will. The advantage of this is that the torque reaction of the propeller can be arranged to suit whichever direction of circuit any actual race is to follow. Another feature is the method of jointing used. By jointing the box in a vertical plane near the rear-end bearings, a complete assembly of gear and pinion, and in this case on occasions also the idler wheel, can be made in the open, thereby insuring perfect meshing of the teeth, which is so important for extremely fine-angle wheels. The body of the box can then be bolted up to the face and the front-end bearings assembled. A thrust tube is arranged on the front end of the box on the propeller-shaft line, thereby relieving the holding-down bolts of any tripping loads that otherwise would have to be taken care of. The box is designed to transmit 1400 hp at 3300 rpm at the input shaft, weighs only 168 lb complete (dry weight) and, as drawn with idler wheel, gives a 2-to-1 increasing ratio. It is water cooled on the bottom half only, and is lubricated by splash lubrication from the box itself, the lower pinion being half submerged in oil.

The box is of cast "Birmabright," a salt-water-resisting alloy, and the shafts and wheels are of special high-tensile steel. (*The Engineer*, vol. 154, no. 4009, Nov. 11, 1932, pp. 477–479, 10 figs., *d*)

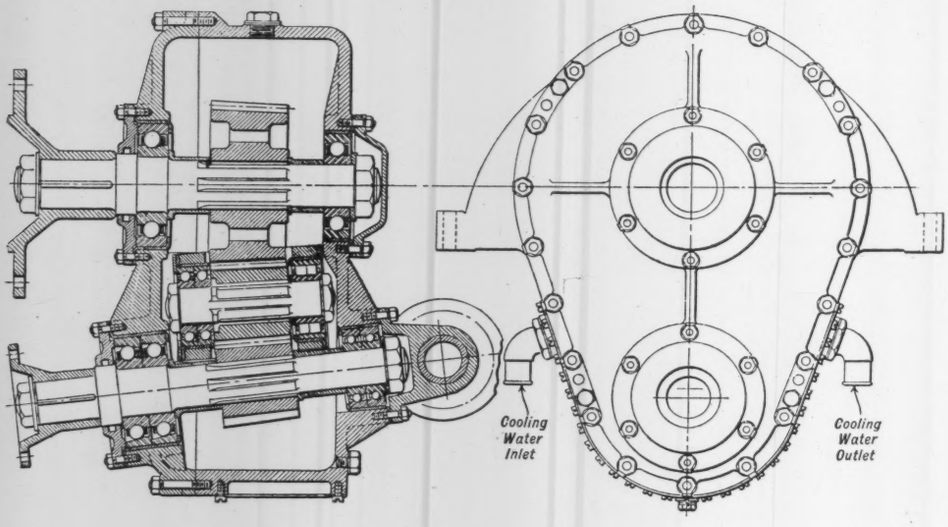


FIG. 2 1400-HP VOSPER RETURN-DRIVE GEAR BOX

IRON AND STEEL (See Power-Plant Engineering: Higher Steam Pressures in the Blast-Furnace–Steel-Mill Power Plant)

LUBRICATION

Some Aspects of Boundary Lubrication by Soap Solutions

IN THE course of a study of lubrication as related to the process of drawing wire, some observations have been made which throw light on boundary lubrication in general. Boundary lubrication pertains to conditions accompanying the relative movement of bearing surfaces separated by relatively thin films of lubricant as distinct from thick, fluid lubrication. High pressures which are localized at points of asperity are concomitant with boundary lubrication.

Wire drawing is accomplished through the application of lubricants to the wire by various means. The condition of localized high pressures exists, and lubricants vary greatly in their ability to facilitate drawing. Lubricants are generally applied in the form of mobile fluids (in which case they act also as coolants), greases or grease-like masses, and powders, as, for example, soap powder. The present report is confined to the study of certain fluid lubricants, involving water as the continuous phase. Little if any fundamental published information exists on lubrication as related to wire drawing.

The evaluation of the lubricant solutions studied, it is stated, was accomplished by drawing wire through a die

and then measuring the pull on the die or the "die pressure."

The experiments were made with a sodium soap solution and with an emulsion of tallow fat in a sodium soap solution. In both cases the relation of concentration to the lubricating effectiveness has been determined. It has been found in the case of the soap solution that as the concentration of the solution was decreased the effectiveness as a lubricant diminished rather sharply. The surface tension has not been measured, but it is believed that had it been measured by a dynamic method, it is quite possible that the upward break in surface tension would have occurred at the same concentration as did the downward break in effectiveness of lubrication. The incorporation of tallow in the soap solution did not alter the trend of the results.

Tests were also made with ammonium soap as a lubricant. It is well known that ammonium soaps hydrolyze to a much greater degree than do sodium or potassium soaps, except in the very dilute range where both hydrolyze almost completely. Ammonium hydroxide, being a weak base, produced a comparatively low degree of alkalinity in the solutions. As the concentration of the soap was decreased, the alkalinity remained remarkably constant.

It is believed that the physical state (degree of peptization) of the fatty-acid particles is a factor which in part accounts for the maximum lubricating efficiency of the solution of the highest molecular concentration.

The conclusion arrived at is that the lubricating effectiveness of sodium and ammonium soap solutions was due to the products of hydrolysis, fatty acid, or acid soap.

When hydrolysis was sufficiently repressed, lubrication by soap solutions was entirely lacking.

When fat (tallow) was emulsified in a soap solution, lubrication was not appreciably affected at low or high pH values.

No parallelism existed between the lubricating effectiveness and the surface tension of the solutions when the pH was varied. However, as the concentration of a given solution was decreased to a point neighboring that at which the lubricating effectiveness diminished rather sharply, the surface tension increased.

There was an indication that the degree of peptization of the fatty acid or acid soap was a factor in lubrication by soap solutions. (Robt. C. Williams in *The Journal of Physical Chemistry*, vol. 36, no. 12, Dec., 1932, pp. 3108–3114, 1 fig., *e*)

POWER GENERATION

By-Product Power From Industrial Steam

A DIAGRAM in the original article shows a more or less typical industrial power plant in its essential parts and operations, including a complete heat balance. In America, by-product-power installations are preferably equipped with steam turbines, and the author enumerates seven methods by which power generation and process steam can be combined.

While there is not available any listing of installations of this class, some idea of their progress on this side of the water may be roughly judged from the following statements:

During the last five years, non-condensing turbine generators for back pressures of 25 lb gage or above for industrial application have been shipped by or ordered from a single large manufacturer, as enumerated in Table 1.

TABLE 1

Kind of industry	Number of units	Total kw
Paper	15	41,000
Steel	1	5,000
Oil	11	42,500
Textile	1	2,500
Rubber	2	5,500
Tobacco	3	2,500
Sugar	2	2,500
Chemical	2	7,500
Salt	1	1,000
Miscellaneous	6	9,500
Total	44	119,500

Of these the highest back pressure was about 200 lb gage, and initial pressure, 600 lb. The average back pressure was about 75 lb gage.

As a notable example of by-product power is cited the combination of interests between E. I. du Pont de Nemours & Co., near Wilmington, Del., and two of the public-service companies where the initial steam pressure is 1400 lb, and the Du Pont steam passes through their high-back-pressure 12,500-kw turbine-generator unit into evaporators which deliver up to 400,000 lb of steam per hr at 180 lb pressure to the industrial plant for general process and service.

During the periods when the Du Pont unit furnishes insufficient power, the balance is drawn from the utility bus. When the Du Pont unit develops more energy from the process-steam demand than can be used by that industry, this excess electrical energy is absorbed by the utility. This arrangement has proved highly satisfactory and mutually profitable to the parties concerned.

Another example from the authors' practice was the installation of a 5000-kw turbine-generator taking steam from the 250-lb boilers already installed and exhausting at 110 lb into the mill service line of a large rubber factory. This lower-pressure steam, which is used chiefly for vulcanizating, was formerly supplied as direct steam from the boilers. The company, which controlled a large interest in the local power company, purchased the bulk of its electricity at about one cent per kilowatt-hour. The new unit was floated on the line in parallel with the purchased power. Its electrical output was automatically controlled from the pressure in the 110-lb process main. The energy generated was therefore always in balance with process-steam requirements. In this manner the process steam was made always to produce its full quota of by-product power, and the balance was drawn from the outside power system.

After charging against the unit all items of interest, depreciation, insurance, operation, fuel costs, and maintenance, the total cost per kilowatt-hour was less than $0.004 (four mills). If a higher boiler pressure had been available, the economy would of course have been even greater. (First instalment of a serial article by David Moffat Myers, of Orrok, Myers, and Shoudy, Consulting Engineers, New York, in *The Steam Engineer*, vol. 2, no. 3, Dec., 1932, pp. 137–140, *d*)

POWER-PLANT ENGINEERING

Savings With High-Pressure Plant

FIFTEEN new turbines contribute to the saving of $1000 a day in steam costs effected by the new steam plant installed by the Pennsylvania Sugar Co., Philadelphia, Pa. These Westinghouse turbines constitute one of the largest single installations of small turbines operating at 150 lb back pressure in the country.

They receive steam at 400 lb pressure and 75 F superheat, and, exhausting at 150 lb, supply steam for many processes throughout the plant. Three of the turbines, rated at 340 hp and 2550 rpm, drive the boiler-feed pumps; eight 100-hp, 860-rpm turbines drive coal pulverizers; two forced-draft fans, of 108,000

cfm each, are driven by 340-hp turbines; and two induced-draft fans, of 200,000 cfm each, are driven by 730-hp turbines.

One of the interesting features of the plant is that it can be started without any external source of power. At the difference between its cost of operation and that of the old plant, the new turbine installation is expected to pay for itself in two years. (*Power Plant Engineering*, vol. 36, no. 20, December, 1932, p. 811, *p*)

Tests of a Simmon Rotary Economizer

THE device here described is a patented combination of a water preheater and blower, the heating surfaces being of the rotary type. An apparatus of this type has been recently installed at a Nuremberg, Germany, pencil factory and tested by the engineers of the Bavarian Boiler Inspection Association. The apparatus used in the test is shown in Fig. 3. It has a capacity of handling from 4 to 6.5 cu m (141.2 to 264.6 cu ft) of water per hr. It consists of a heating unit *a* built in two parts and airtight, holding a rotor *b* consisting of finned tubes *c*, through which water is flowing. The heating gases are drawn in through *d*, and as a result of the rotation of the tubes are thrown against the outer walls of the housing and forced through the connection *e* into the smokestack. The heating surface consists of a large number of copper tubes *f* only 30 mm (1.18 in.) in diameter, set over sheet-steel strips *g*. These strips are of trapezoidal form and are countersunk at the holes. The width of the slot between the strips is from 3 to 4 mm (0.118 to 0.157 in.). The tubes are arranged in the axial direction in four rows. Connection between the copper tubes and the sheet-steel strips is effected by inserting the tubes and submitting them to an internal water pressure of some 600 atm gage. This presses the soft copper on to the hard sheet steel. Because of this method of manufacturing the device is very suitable for installations working at high pressures. The ends of the tubes are rolled into receivers *h* made of malleable iron. This method of connecting is illustrated in more detail in Fig. 4 which shows plugs of delta metal; these plugs must be taken out when the inside surfaces of the tubes are cleaned. The cleaning may be effected mechanically or preferably chemically, the latter being more suitable because of the small size of the tubes, but its application depends on the character of the deposits.

When high gas velocities are used, at least with the fuel employed in the plant under observation (bituminous coal and wood refuse), the outside of the tubes keeps automatically clean. It has been found elsewhere that the same holds good for plants using raw brown coal as a fuel, this being due to the fact that there is no extensive cooling of gases and no condensation of steam. If necessary, however, the tubes can be blown out during operation with steam or compressed air. No attacks at the place where the copper tubes connect with the sheet-steel frames as a result of electrolytic action have been observed on the experimental apparatus.

The rotary frames and the tubes with their sheet-steel strips are held by sheet-steel disks *i*, of which the two located on the right are rigidly attached to flanged collars fixed to the shaft, while the disk located on the left acts only as means to stiffen the tube assembly. The water enters at *k*, flows through the hollow shaft of the rotor, and by means of the flexible tube *l* reaches the heat exchanger. Thence it goes through another flexible tube *m* and a passage inside the shaft to the exit connection *n*. At the water inlet and outlet the shaft passes through stuffing boxes as shown in detail in the original article. The water first flows through the outermost row of tubes, then through the two middle rows, and finally through the innermost row. As the flow of water takes place toward the inside wall and the flow of gas is directed toward the outside, it may be said that the operation is in counterflow.

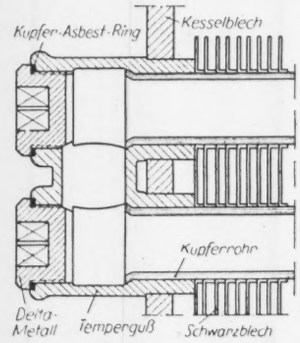


FIG. 4 DETAILS OF ECONOMIZER TUBE JOINT IN THE SIMMON ROTARY ECONOMIZER

(*Kupfer-Asbest-Ring* = copper-asbestos ring; *Kesselblech* = boiler plate; *Kupferrohr* = copper tube; *Delta Metall* = delta metal; *Temperguss* = malleable-iron casting; *Schwarzblech* = black steel plate.)

The velocity of water flow when handling 4000 kg (8818 lb) per hr is about 0.4 m per sec, in the outermost and innermost row of tubes, and in the middle row of tubes, about 0.2 m per sec. The total heating area of the heat exchanger is about 250 sq m, and the permissible pressure about 35 atm gage. The rotor is supported by two water-cooled SKF roller bearings and is belt driven from an electric motor of 5.5 kw capacity. The speed of the rotor is 365 rpm. The housing of the exchanger is heat insulated from the outside to minimize radiation and convection losses.

Figs. 5 and 6 show the way the experimental installation has been built into the plant. Altogether there are three boilers. The one that is lettered "Steilrohrkessel" of the heater is fed with wood waste, chiefly very fine shavings, and is of the inclined-tube type with 50 sq m (538.18 sq ft) of heating area and an operating pressure of 11 atm gage. This boiler generates ex-

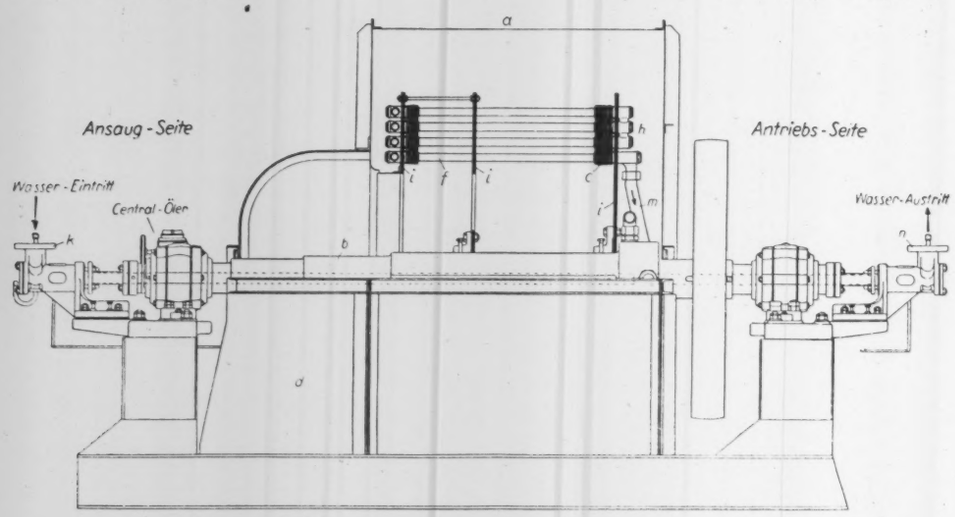
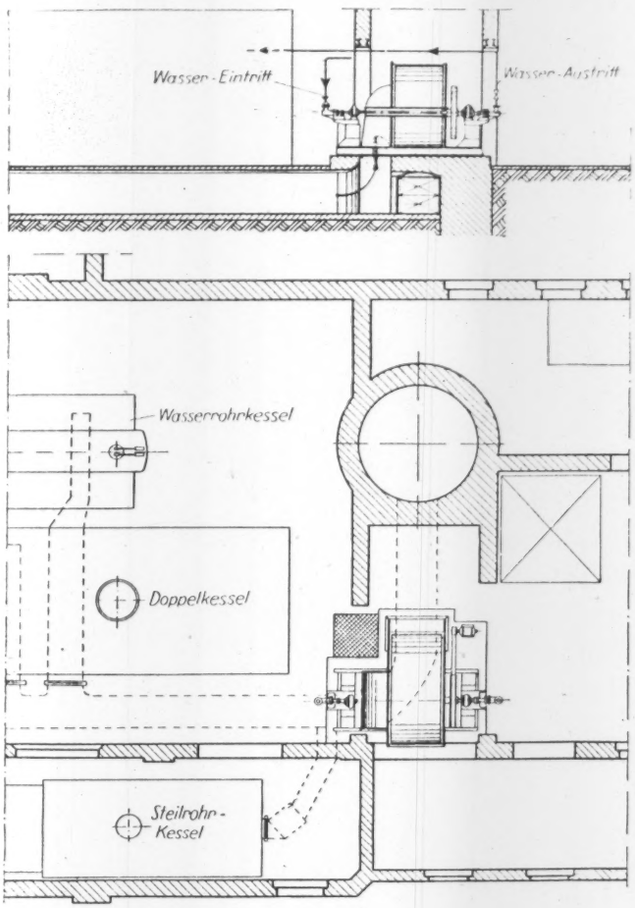


FIG. 3 THE SIMMON ROTARY ECONOMIZER

(*Ansaug-Seite* = suction side; *Wasser-Eintritt* = water inlet; *Central-Oler* = central oiler; *Antriebs-Seite* = drive side; *Wasser-Austritt* = water outlet.)

clusively saturated steam for process purposes. The middle boiler is of the fire-tube type and burns bituminous coal on a plain grate operated with a stoker. It has a heating surface of 185 sq m and a maxi mum operating pressure of 11 atm gage. This boiler generates superheated steam to run a back-pressure steam engine, and also saturated steam for heating and process purposes. The boiler at the top is of the water-tube type with a plain grate equipped for burning bituminous coal and has heating area of 104 sq m and an operating pressure of 10 atm gage. This boiler also generates saturated steam. The new economizer heater is large enough to operate all three boilers, but during the test period only the inclined-tube and the fire-tube boilers



FIGS. 5 AND 6 DETAILS OF INSTALLATION OF THE SIMMON ROTARY ECONOMIZER

(*Wasser-Eintritt* = water inlet; *Wasser-Austritt* = water outlet; *Wasserrohrkessel* = water-tube boiler; *Doppelkessel* = double-flue boiler; *Steilrohrkessel* = Stirling-type boiler.)

with a combined heating area of 235 sq m were in operation. The uptakes of the two boilers join just ahead of the new heating device and the gases back of the apparatus are forced into the smokestack through a short passage, the smokestack being 40 m high and having an inside diameter of 1.1 m.

The suction and pressure connections are equipped with rotary valves, in addition to which a bypass valve is provided permitting the gases to go directly into the smokestack. Notwithstanding the lack of space there was no particular trouble in installing the new device, and its small floor space must be counted as an advantage.

As feedwater was used the condensate from process operation and the heating plant, as well as treated raw water. This water was treated *in situ* by trisodium phosphate. Reciprocating pumps which were already available forced the water through an exhaust-steam preheater into the new economizer heater. The original article goes into considerable detail as to the methods of testing and the processes of measurement adopted. Two tests were carried out, one in the morning and the other in the afternoon, of which the original article gives details, together with a table of results. These latter indicate a very satisfactory performance. (Dr. of Engg. F. Kaiser, in *Zeitschrift des Bayerischen Revisions Vereins*, vol. 36, nos. 19 and 20, Oct. 15 and 31, 1932, pp. 213-215 and pp. 225-228, 10 figs., *ed*)

Savings by Use of the Mercury Cycle

INVESTMENT costs per kilowatt-hour for mercury-steam-cycle generating equipment now under construction and installation, are estimated by A. R. Smith, managing engineer, turbine department, General Electric Company, to be lower by 31 per cent than the comparable costs for the nearest competing form of generating facilities. Mr. Smith, in speaking at the annual meeting of the New York Railroad Club last week, outlined some of the elements in the engineering decision to proceed with other mercury-vapor plants following the experience gained with General Electric equipment at the plant of the Hartford Electric Light Company.

Approximately 300,000 lb of process-steam capacity was needed by General Electric at Schenectady, and preliminary estimates indicated that facilities to supply this at 200 lb per sq in. gage would have cost about $1,600,000 without any power generation whatever. A 400-lb, 750-deg steam plant generating 7400 kw and 300,000 lb of process steam would have cost $2,500,000. A 1200-lb plant generating 14,000 kw would have cost $3,000,000. The cost of a 26,000-kw mercury-steam plant was estimated at $3,400,000. The net investment per kilowatt was figured as: 400-lb steam, $128; 1200-lb steam, $100, mercury-steam, $69.

That the cycle adopted for Schenectady comes close indeed to 100 per cent theoretical efficiency was one of Mr. Smith's contentions. The use of the process steam raises the cycle efficiency there to nearly 100 per cent, as compared with the 59 per cent available in the Kearny, N. J., installation of the Public Service Electric & Gas Company. That the relatively low-pressure cycles in general use have a cycle efficiency of about 32 per cent and that 1200-lb plants have a corresponding figure of about 47 per cent was also pointed out.

At Schenectady the mercury is to be raised to 125 lb gage, 950 F, bringing the steam to 400 lb gage as it leaves the mercury unit and being taken from the steam turbine at 200 lb gage for process use.

So definitely do the construction elements and contractual phrases coordinate that the Schenectady project must be viewed not as a by-product steam undertaking but as a by-product electricity project. Steam generating for General Electric is the major object, and the production of electrical energy by the lessee, the New York Power & Light Corporation, is but the incidental purpose. (*Electrical World*, vol. 100, no. 22, Nov. 26, 1932, p. 713, *g*)

Higher Steam Pressures in the Blast-Furnace–Steel-Mill Power Plant

THIS paper discusses how far the compound blast furnace and steel mill should go in adopting the higher steam pressures and temperatures which have been so extensively introduced in power generation in public-utility plants.

A few steel-mill power plants have been built for pressures

of 400 to 500 lb and are producing most satisfactory results. But there is still much uncertainty among steel-mill executives and engineers as to whether these higher pressures are suitable, particularly for the blast-furnace–gas-fired power plant. The present article aims to set forth as simply as possible the true situation as to higher pressures and temperatures in the blast-furnace–steel-mill steam power plant.

There has been a change of attitude toward blast-furnace gas, which at first was regarded exclusively as a fuel to be used under boilers and in hot-blast stoves. Today, instead of its value being equivalent to the amount of steam coal it would replace, it must now be regarded as equivalent to the amount of gas-producer fuel, operating cost, and fixed charges that it can replace.

In order to show the relative values of different pressures, practical heat balances are given for a blast-furnace–steel-plant power and steam system with different pressures, temperatures, and types of heat cycle. The fundamental data used for all cases are as follows:

Electrical energy required	25,000 kw
Blast-furnace blowing at 20 lb per sq in	240,000 cfm
Steam required for miscellaneous uses outside the power plant, assumed in all cases to be delivered at 150 lb per sq in. gage	167,000 lb per hr
Power for driving power and blowing-plant auxiliaries, equivalent to an output at generator terminals of	2,000 kw
Vacuum in all condensers	28½ in.

The authors consider next five different layouts of plants operating with and without resort to regenerative cycles and with and without separate evaporators. Two tables are given, one showing the work done by the boilers and superheaters and boiler surface required for the various cycles, and the other showing the total steam generated per hour and total heat added to feedwater in boilers in the various cycles. The conclusion at which the authors arrive is that there are advantages in the regenerative cycle, higher pressure, and use of a non-condensing turbine as a reducing valve.

A review of the principal items entering into the cost of a steam power plant is given to show what a small proportion of them are influenced by the steam pressure used. (C. W. E. Clarke and Walter P. Gavit, Engineers, United Engineers and Constructors, Inc., Philadelphia, Pa., in a paper before the Association of Iron and Steel Electrical Engineers, Pittsburgh, June 22, 1932; abstracted through *Iron and Steel Engineer*, vol. 9, no. 11, Nov., 1932, original paper pp. 493–497, and discussion, pp. 479–498, *dp*)

The Michigan City Central Station

THIS is a modern station in northern Indiana—640 lb, 750 F, direct-fired pulverized fuel, water walls, slag-tap furnaces, and four stages of extraction heating. Since its installation the plant has operated at an average load factor of over 70 per cent, and the operating performance has steadily been within 1 per cent of the design figures.

Although steam was not turned on the turbine prior to the formal opening of the station, the load was picked up and carried immediately. No extended "tuning up" was needed, nor were major equipment changes or replacements made. That only minor difficulties were encountered is shown by the fact that the turbine operation factor for the first year was 95.6 per cent and the average boiler availability factor was 72.46 per cent.

Changes made in equipment and in operation since the plant went into service are all of a very minor nature, perhaps the most interesting being in connection with the feedwater system. Make-up to the system is evaporated and is a small percentage, averaging but 0.35 per cent over the year. Evaporators are operated continuously at as low a rate as possible, usually from 3000 to 5000 ib per hr.

Evaporator feed is harbor water filtered through a sand filter and taken from the service water lines. Until recently no evaporator feed treatment was used, but now a batch lime treater is used and about a quart of lime added for every 100,000 lb of water evaporated. This treatment was added to reduce the CO_2 in the evaporator vapor. The lime has not only reduced the CO_2, thus increasing the pH reading of the distillate, but has reduced carry over and eliminated scaling. Previously the evaporator was cracked every 24 hr. Now the unit can be run for 72 hr without blowing down, and the impurities settle down in a sludge easily blown out without cracking.

This was one point where early difficulty developed. The deaerating condenser hotwell is fitted with an internal hood to conduct liberated gases to the air-cooler section of the tube bank. The low-level float chamber was originally installed with the upper connection above this hood. During periods of increasing load the boiler-feed pump would pull down the level, opening the valve from the storage reservoir. Incoming water at about 120 F would flash, building up a slight pressure which would tend to close the valve in spite of the falling water level. This condition was corrected by lowering the upper float connection below the cone so that both connections were subjected to the increased pressure.

Originally the bottom of one of the furnaces was entirely air cooled and two leaks developed through the air-cooling pipes, slag ran down the air piping and hardened around the periphery of the pipe, gradually filling it up until only a small circular passage in the center of the pipe remained. Later the air-cooling pipes were removed from the center section, leaving a solid bottom with only a strip 4 ft from the walls air cooled.

Some experiences with the automatic coal sampler in the breaker house are described, and also with the burning of petroleum-coke screenings. (*Power Plant Engineering*, vol. 36, no. 20, Dec., 1932, pp. 796–803, 8 figs. and a tabulation of the principal equipment, *d*)

Removal of Oil From Water

THE methods of removing oil from water may be classified as mechanical, electrical, and chemical. The first of these usually separate the water and oil by means of baffle plates. The Davis Perrett oil separator operates by electrolysis of the condensate. The hot condensate is passed through a tank divided into sections which are subdivided by iron plates. These plates serve as electrodes, and about 50 volts potential is used across each plate. The feed is mechanically filtered after coagulation has occurred, wood-wool or sand filters being used. The plates last about two or three years, and may be cleaned of deposit (even when badly covered) by reversing the current. A Dutch engineer has described a similar method of dealing with emulsified oil. The tiny globules of oil are made to coalesce by passing an electric current through the water. He uses 110 volts continuous current while the water flows through the feed pipe. The electrically treated water is then filtered by means of a pressure filter. This consists of perforated cylinders covered with cloth and enclosed in a suitable vessel. Since the globules of oil are increased in size by the electric current, this filter removes all the oil. A pressure gage on the filters indicates when the cloths require changing.

When it comes to emulsions, these may be stable or unstable. In many cases where the stability of an emulsion is due to the electrical charges upon the droplets, the emulsion may be broken by the addition of suitable electrolytes. The added ions neutralize the charges upon the particles and so lead to the breakdown of the emulsion. Similarly, we might have small particles precipitated on the surface of the oil globules if they were charged with electricity of a sign opposite to that on the oil droplet. The electrical charges would cause an attractive force. If, then, oil globules will collect small particles of certain solids around them, the filtering of an oil emulsion through a large mass of these substances should filter off the oil and give a clear filtrate. This is exactly what was found to be the case. Filter media formed of the following substances gave a clear filtrate: hydroxides of iron, aluminum, chromium, and calcium, barium carbonate, bone black, spongy iron, and finely ground coke; but when cotton wool was used little or no oil was removed. Hatschek found that filtration through magnesium or calcium carbonate would also remove all the oil.

Oil may be also removed by the addition to the water of aluminoferric and soda ash or caustic soda followed by filtration. On account of its corrosive properties it is important to avoid the presence of any undecomposed aluminum sulphate in the treated water, which should contain a slight excess of caustic or soda alkalinity.

A recent development consists in the use of sodium aluminate. The arrangement is to have two solution tanks, one for filter alum or aluminum sulphate and the other for sodium aluminate, each feeding small constant-level tanks fitted with taps. The quantities of chemicals should be adjusted to leave a slight alkalinity in the effluent. Filter alum or aluminoferric is acid, while sodium aluminate is alkaline; therefore these two together quickly neutralize each other to form sodium sulphate, liberating alumina. This results in a double coagulation which is very effective in removing the oil.

It should be emphasized that sodium aluminate contains alumina and is also alkaline, so that it is more useful than caustic soda or soda ash in the oil-removing plant. By using a slight excess of sodium aluminate in the condensate, therefore, the corrosive effect of filter alum is eliminated.

Oil removal in this way is exceptionally efficient, and it has been stated that the method be adapted to remove quantities as low even as 0.1 grain of oil per gallon. (F. J. Matthews in *Colliery Engineering*, vol. 9, no. 103, Sept., 1932, pp. 312–313, *p*)

Operating Results at the Seaboard Plant

THE Seaboard Power Station belongs to the Dominion Steel and Coal Corporation and is located at Glace Bay, N. S. It was put into operation in May, 1930, and is operated as a subsidiary under the name of Seaboard Power Corporation, Ltd. Present operating results show a heat consumption of 19,000 Btu for the net power delivered from the plant, so that the station can be said to have an actual plant efficiency of 47.5 per cent. A diagrammatic arrangement of the cycle and a heat-balance diagram are given in the original article. The turbine is of the Brown-Boveri combined type with one impulse Curtis stage and 22 reaction stages, the rotor blading in the former being of nickel steel and in the latter of stainless steel, while all the fixed blading is of monel metal.

It was considered that the system as designed, by the action of the condenser and air pumps, would automatically rid the system of any dissolved oxygen in or leaking into the system, so that any treatment of the feedwater would not be necessary. Apparently two sources for this were not fully taken care of. First was the open surge tank, the surface of the water being at all times in contact with the atmosphere; second was the steam being bled from the turbine and not passing to the condenser, and which amounts to about 25 per cent of the total steam flowing to the turbine.

Although it would be thought that in time this would be eliminated by the fact that the condenser is always in operation on 75 per cent of the total, this was not accomplished in fact, and tests continually proved that the condensate taken from the heaters before being mixed with the water from the main condenser and going to the boiler feed pump, contained an excessive amount of dissolved oxygen. It was decided finally to install a deaerator (home-made) on this drain-pump discharge, through which all this condensate now passes.

This was put in operation in April. The surge-tank connection to the system had been previously changed to feed direct into the hotwell where the deaerating effect to the condenser would take care of the oxygen from this source. Two ejector air pumps in operation, instead of one, have been found to help further in this respect.

It can now be said that as a result of the above changes, oxygen has been practically eliminated as a corrosion factor in the operation of the system.

The fuel used at the plant consists of a waste splint coal taken from the picking belts of the collieries. It is of a hard, stone-like nature, with about 65 per cent combustible. As regards pulverizing, the coal passes through a ring-type crusher on its way to the feed bin over the mills. The product of this crusher as at first operated was up to $1^1/_2$ in. in size.

This coarse coal decreased the capacity of the mill considerably, especially on night shifts, where segregation of the coarse from the fine coal in the bin brought all the coarse down together after the fines had been run off. Closing the sieve screen or bars in the crusher brought the product of the crusher down to a size minus three-eighths of an inch, and this has increased the capacity of the mill to such an extent as to practically eliminate all two-boiler operation except for very adverse conditions. A hot-air connection to the coal-inlet end of the mill has helped considerably in this respect also when handling wet coal. (Mark W. Booth in *Power House*, vol. 26, no. 11, Nov., 1932, pp. 22–27, 5 figs., *d*)

PUMPS

The Rannett Large-Capacity Pipe-Line Pump for Outdoor Service

THIS pump has been designed and invented by D. J. Moran, president of the Continental Oil Co. and E. O. Bennett, chief engineer of the same company. One such pump was built for the Great Lakes Pipe Line Co. and is operating at station No. 5-A at Paradise, Mo.

The motor and pump are connected together through a central spacer section in a manner which prevents deflection from any external forces. The motor has its stator laminations in a double-walled housing. In operation the fluid being pumped enters the double-walled section of the motor from the pipe line which is parallel and in line with the shafts of the unit. The inlet to the motor is at the top and bottom of the unit at the outboard end. This arrangement provides access to the outer motor bearing. After the fluid in the pipe flows spirally and laterally around the motor it leaves at the top on the inner end, over the spacer section between the pump and the motor to the pump intake. There is no pressure in the spacer section, it being vented to atmosphere through finely screened louvers. The inside bearings of the motor

and pump, between which is a Fast flexible coupling, are inside the spacer section. In the bottom of the spacer section there is an oil reservoir which holds approximately 40 gal of lubricating oil.

The pump is an eight-stage unit with two sets of impellers of four stages in opposed arrangement to equalize end thrust and to take the high-pressure discharge from the center of the pump between the sets of impellers. The flow through the pump is from the inside or motor end through the first four stages in series, out the top of the pump to the outboard end, through the second series of four impellers toward the center of the pump. The discharge is parallel to the axis of the pump and is carried inside the loops between stages for compactness. The loops between stages are below the center of the pump and the discharge pipe is carried upward at an angle to the center line of the unit. A false arm is carried from the discharge line up to the conductor between stages, but is used for a brace only and forms a guard over the outer pump bearing and Kingsbury thrust bearing while the unit is in transit.

The full-load efficiency of the motor is 96.5 per cent with a power factor of 92.5 per cent. This high efficiency is said to be due to the design, which eliminates the windage friction loss. The fluid-cooling system incorporated in the motor helps toward low losses. The pump shows an efficiency of 83.2 per cent at 1058 gal per min against a head of 25.02 ft. This gives the unit an overall efficiency of 80.18 per cent. The unit weighs approximately 18,000 lb complete, and is designed for across-the-line starting without autotransformers or reduced voltages. A complete supervisory unit for remote control has been designed and will permit operating the pump from Kansas City, forty miles distant. The supervisory control will operate in sequence the motor and motor-controlled valves for starting and stopping the main pump. A hot bearing will be indicated and the unit stopped, a reduced pressure or loss of pressure indicating a break in the discharge line will be indicated and the motor stopped, also a lack of fluid on the suction will be indicated and the unit shut down. Twelve separate operations will be handled by the control, thereby giving a complete indication of operation. (*The Oil and Gas Journal*, vol. 31, no. 19, Sept. 29, 1932, pp. 12–13, illustrated, *d*)

RAILROAD ENGINEERING

Pneumatic-Tired Rail Cars in Austria

THE Austro Daimler-Puchwerke Co. in Vienna has developed a pneumatic-tired rail car built in single, twin, and triple form and designed for use at speeds of 60 to 75 mph. The wheels comprise two distinct detachable disk wheels, the outer ones having steel flanged tires running directly on the rails, while the inner ones have pneumatic tires bearing against the internal flat surfaces of the steel tires. The pneumatic-tired wheels have their own axle which bears the load and is connected in the usual manner by leaf springs to the chassis. Owing to the fact that the pneumatics are not in contact with the rails, but are located within the very wide drums of the steel running wheels, it is possible to increase the load capacity of each wheel to any desired extent. In other words, the load capacity is not dependent upon the narrow profile of the rail either for standard or narrow gages. The outer wheels with steel flanged tires are attached and supported through ball bearings on the hollow axle casing.

It is claimed that an important advantage of the new Austro-Daimler system is its ability to absorb not only the vertical shocks produced by the rail joints, but also the horizontal shocks produced when the vehicle is running through points and crossings on curves and when moving at high speeds. Further, even should a puncture occur, there is no need to make a special stop for the purpose of wheel changing. In the event of a puncture, the load-carrying axle of the pneumatic wheels sinks $^3/_4$ in. down until the ball-bearing casing rests on the guiding axle, thus temporarily converting it into a load-carrying axle. This, of course, reduces the amount of riding comfort for the time being, but as punctures are very unlikely to occur, and the deflated tire can be easily and quickly changed during the time that the rail car stands at the next station, very little inconvenience is likely to be caused.

The car is driven by a six-cylinder gasoline engine with transmission by universal joint and bevel gears, the gear box incorporating four speeds and reverse and a free-wheel device. The twin and triple cars are driven by two engines, one at each end of the train, each engine having its own gearbox and transmission system, and the gears are hydraulically operated from both ends of the vehicle or train. There is no connection between the two power plants, and to avoid difficulties in synchronizing the two engines, hydraulic clutches instead of mechanical clutches are employed.

On a wheel base of 17 ft 3 in. it has been found possible to design a standard body for 30 passengers, including auxiliaries.

The chassis is designed as a lattice girder, and this, together with the shock-absorbing action of the pneumatics, permits the use of bodies of very low weight. (*The Railway Gazette*, vol. 57, no. 18, Oct. 28, 1932, pp. 517–519, illustr., *d*)

SPECIAL MACHINERY

Krupp Tube Mill With Air Separation and Drying System

IN THIS mill, which was recently erected at the Wittekind cement plant, the raw hard lime marl is precrushed to about 12 in. in a jaw crusher. After the necessary coke has been added it is crushed to a maximum of 3 in. in a hammer mill and then delivered to the reserve bin of the closed-circuit grinding mill with air separator and mill drying system. The details of the machine are described and illustrated in the original article.

Numerous tests and measurements on the installation gave the following data: The mixture of hard lime marl and about 10 per cent coke has a granular size of 0 to 80 mm (3 in.) and a moisture content of 4 to 6 per cent. The mill, of 3 m (10 ft) inside diameter, with 18 tons of balls of 40 to 80 mm ($1^1/_2$ to 3 in.) has a speed of 18.5 rpm, a load capacity of 270 hp, and an output of 18 to 22 tons per hr, depending on the fineness of grinding. The fan has a capacity of 45,000 cu m (1,589,170 cu ft) per hr, a total pressure of 510 mm (20 in.) of water, a load capacity of 125 hp, and an efficiency of 68 per cent. The raw meal has a fineness of 22 per cent average residue on a 4900-mesh (178 mesh) screen. Lime marl and coke of a moisture of 0.4 to 0.8 per cent are used. Heating gases of 310 to 500 C are added, amounting to 7500 to 8500 kg (16,500 to 18,700 lb) per hr, depending on the moisture content. The temperature of the circulating air is 115 C at the mill inlet and 78 C at the outlet; the exhaust air before entrance to the wet dust eliminator at 60 deg saturation has a temperature of 55 C. From 600 to 1000 kg (1320 to 2200 lb) of water are evaporated per hr, depending on the moisture. From 900 to 1000 cal (3600 to 4000 Btu) of heat are required per kg (2.2 lb) of water evaporated. (*Tonindustrie Zeitung*, 1931, vol. 52, no. 82, pp. 1147–1149. Compare *Rock Products*, vol. 35, no. 19, Sept. 24, 1932, pp. 38, 1 fig., *d*)

The Arthel Heliostat

THE purpose of this apparatus, invented by Jacques Arthuys, is to provide sunlight to structures which would be deprived of it otherwise. It consists of a series of mirrors so arranged as to reflect the sunlight to the ceilings of rooms in a building. An installation of this kind has been made for lighting a stairway of the new building that is to house the Paris daily newspaper, *L'Intransigeant*. Space is lacking to describe the heliostat in detail. One of its most interesting features is a device developed by M. Bayle, collaborator with M. Arthuys, by means of which the motion of the reflecting mirrors is controlled by the sun itself.

The Bayle apparatus consists of a series of reflecting mirrors which direct part of the sunlight to the mirrors illuminating the desired building, and some of it to a lens of the burning-glass type, the heat of which activates a contactor switch which energizes or deenergizes an electric motor.

It is stated that the main mirror, 4 sq m (43 sq ft) in area, gives in the latitude of Paris a maximum illumination equivalent to 400,000 lumens, and an average illumination of 320,000 lumens during nine months of the year.

Instead of distributing this total illumination to the various rooms by means of additional reflectors, a series of lenses is used. It is believed that the insolation of rooms provided by the heliostat for offices, stores, and factories so located that without the heliostat they are compelled to use artificial illumination, will result in a material saving of the latter. (Paul Calfas in *Le Génie Civil*, vol. 101, no. 12, Sept. 12, 1932, pp. 281–284, 5 figs., *d*)

SPECIAL PROCESSES (See Power-Plant Engineering: Removal of Oil From Water)

TESTING AND MEASUREMENTS

Accelerated Testing of Metals for Resistance to Erosion

THE present article describes work done at the laboratories of the Westinghouse Electric & Manufacturing Company on the behavior of various alloys when subjected to a rapid erosion process. The testing apparatus consisted essentially of an impeller disk into the rim of which were inserted two test pieces at diametrically opposite points. Two fine jets of water parallel to the impeller shaft cross the path of the test piece approximately 1 in. away from the rim of the disk. Thus each specimen struck an unbroken jet of water twice per revolution. The disk revolved at 20,000 rpm for the maximum peripherical speed of 1200 fps. Although the test did not exactly simulate conditions to which most machine parts are exposed, the erosion produced is similar in appearance to eroded surfaces in practice. The erosion produced in a few minutes of test represents several years of wear under average operating conditions. It has been found that at the lower speeds, 600 and 800 fps, the water spray had no effect on any of the materials tested, which were 0.40 plain carbon steel, nitrided steel, nickel steel, and two chrome-nickel alloys. At 1000 fps some of the metals showed the effect of spray, while at 1200 fps excessive wear was shown on several of the materials.

The spray erosion may show results entirely different from those of jet erosion. In general the hardest materials offer the greatest resistance to erosion, but there are exceptions to this rule. Erosion increases with an increase in speed, and as the speed is increased above 800 fps, differences in loss of weight between the various metals increase.

At the higher speeds even the case-hardened material (F) has been eroded through the hard case after 200,000 impacts at 1200 fps. If the test were continued beyond 200,000 impacts the soft matrix would begin to wear rapidly. Thus the hard case tends to delay the beginning of excessive erosion. (P. F. Hengstenberg, Research Laboratories, Westinghouse Elec. & Mfg. Co., in *Power*, vol. 76, no. 3, September, 1932, pp. 118–120, 4 figs., *e*)

THERMODYNAMICS

The Design of Heat Exchangers

IN MODERN engineering practice there is said to be an increasing tendency to use parallel flow instead of the more efficient counterflow where it is of primary importance that the temperature attained by the metal should be kept as low as possible. One of the most familiar examples is that of the separately fired steam superheater, where it is the usual practice to work the first few tubes facing the hottest gases in parallel rather than counterflow in order to keep down the tube temperature and avoid internal and external oxidation and "bagging." With most modern boiler installations, owing to the tendency to go toward higher superheats, interdecking superheaters are worked in parallel flow. The author derives a series of equations for counterflow and parallel flow. He arrives at an equation (No. 16 in the original article) of the form originally derived in a rather different manner by Maker and Thornburg in "Economic Features of Heat-Exchanger Design" (MECHANICAL ENGINEERING, 1924, p. 891). He converts it into an expression in terms of the rise in temperature of the colder fluid. From this he proceeds to a derivation of equations for parallel flow and arrives at the following expressions:

$$E = \frac{T_1 - T_2}{T_1 - t_2} = \frac{1 - e^{\frac{RS}{W_1}\left(1 + \frac{W_1}{W_2}\right)}}{1 + \frac{W_1}{W_2}}$$

and

$$\frac{t_1 - t_2}{T_1 - t_2} = \frac{1 - e^{\frac{RS}{W_1}\left(1 + \frac{W_1}{W_2}\right)}}{1 + \frac{W_2}{W_1}}$$

Where E = efficiency of the heat exchanger
T_1 = inlet temperature of hotter fluid
T_2 = outlet temperature of hotter fluid
t_2 = inlet temperature of colder fluid
t_1 = outlet temperature of colder fluid
P_1 = weight of hotter fluid flowing in unit time
P_2 = weight of colder fluid flowing in unit time
R = heat-transmission coefficient
S = heating surface
C_1 = mean specific heat of hotter fluid
C_2 = mean specific heat of colder fluid
$W_1 = P_1C_1$
$W_2 = P_2C_2$

From this he derives the relation

$$\frac{RS}{W_1} = \frac{1}{1 + \frac{W_1}{W_2}} \log_e \left(\frac{1}{1 - E\left(1 + \frac{W_1}{W_2}\right)} \right)$$

By means of these expressions a single one is obtained for a comparison of the amounts of heat transfer in parallel and

counterflow. This is given in the original article as Equation [22] and Equation [24]. The author proceeds to a discussion of the meaning of the efficiency E of the heat exchanger. E can only approach 100 per cent with an infinitely large value of S, the heating surface, when the ratio of W_1 to W_2 is less than unity. When W_1/W_2 is greater than unity, it is not possible for the efficiency to approach 100 per cent, as the author shows from another equation. He next obtains an expression for the heating efficiency: $E' = (t_1 - t_2)/(T_1 - t_2) = W_1E/W_2$.

The author gives as an example in the use of the equations or charts the equations of a steam superheater of the interdeck type and shows how they are applied to that case. From this it would appear that a steam superheater working in parallel flow would absorb 0.915 of the heat transferred in counterflow, and both the superheater and the gas drop would be 0.915 of the values obtained in counterflow. From the equations and the graphs in the original article it may also be seen that a superheater working in parallel flow throughout to give the same duty as a similar superheater in counterflow would require an increase in the heating surface of about 19 per cent. Because of this, parallel flow is only employed where the conditions are such that, in counterflow, installation or maintenance charges are likely to be high. (Brian Thornton in *Engineering*, vol. 134, no. 3485, Oct. 28, 1932, pp. 500–501, 6 figs., *t*)

WELDING

The Future of Acetylene Welding

THE oxyacetylene method of applying hard facing has enabled the metallurgist to compound metals with little regard to the cost of the ingredients. The homeopathic amounts used at the exact point of need make even the most costly compound economic in the end. Thus millions of dollars' worth of heavy-duty machinery is protected by hard facing. Oil-well drills can be kept in service thousands of feet under ground for long periods without having to be withdrawn for dressing, grinding mills continue to turn out their product at lower cost, and industry is served in numerous other ways.

The cutting blowpipe, once chiefly the ally of the wrecker, became the tool of the builder. By application of machine control a once undreamed-of accuracy of size and smoothness of cut became an every-day fact. Today oxyacetylene cutting rivals in finish any but the most perfect of machined cuts; its accuracy is sufficient for by far the bulk of manufacture. Similarly the oxygen lance once used to dismantle large masses of metal became refined into the scarfing blowpipe for removing imperfections from the surface of billets and slabs in the process of steel rolling. Thus the chipping dock, long the bane of the steel mills, fades into the realm of forgotten ills.

While the progress in the past has been substantially much greater, changes are to be expected. The efficiency with which the heat of the acetylene flame is used in welding leaves room for much improvement.

It is expected that welding will be applied to new materials, and, for example, that aluminum and its alloys will be gas-welded more extensively. Also new copper alloys will be used with welding as a method of fabrication.

Less clearly predictable but almost as certain of realization is the use of plastics and glasses in new ways. The construction of large glass chemical equipment and the facing and ornamentation of buildings may be examples. Some predict glass furniture, but from the author's experience with the frailties of even the strongest wooden chairs, that prospect cannot be looked forward to with equanimity. Plastics are certainly forging ahead with great strides. Whatever the material, sometime, somewhere the problem of joints must be faced. Oxyacetylene welding is a perfectly reasonable answer if those who are keenly interested in the process have the vision, wisdom, and energy to grasp the opportunity.

The newer techniques of blowpipe adjustment and manipulation certainly open new opportunities in familiar fields. Speeds of welding are today taxing the ability of the human eye and nerve to keep pace with them, and a little further increase will require automatically controlled machinery to insure sound welding. The oxyacetylene blowpipe will be also used for certain kinds of heat treatment. One may look forward to substitution of the oxygen jet for heavy cutting tools such as roll-turning lathes, boring mills, and planers. Further research and development may be expected to help in this direction. (James H. Critchett, Union Carbide and Carbon Research Laboratories, in an address before the International Acetylene Association, Philadelphia, Pa., Nov. 16–18, 1932, abstracted from mimeographed copy, *g*)

A New Process for Making Welded Joints

THE author of the present paper claims that he has developed a new method of welding steel in which the welded union is effected by heating the parts to about the same temperature that is employed in forge welding and then uniting them by molten filler or weld metal as is now done in fusion welding, it being stated that the molten weld metal unites and becomes integral with the adjacent solid parts by utilizing a number of peculiarly cooperating properties of carbon and iron.

In explaining the metallurgical mechanism of this method of welding, the author states that if we heat steel containing, say, 0.35 per cent carbon and whose melting point is about 1500 C, to a temperature somewhat below this, such as 1200 C, and then expose the metal to a carburizing influence, the surface layer of the white-hot steel will absorb carbon and will spontaneously melt as soon as the carbon content approaches $4\frac{1}{2}$ per cent.

If molten steel is allowed to run over the surface of the white-hot steel thus carburized, the molten surface film is immediately dissolved in the molten steel, which thereupon unites with the underlying solid metal. The necessary carbon is available and controllable with standard oxyacetylene-welding apparatus, and in practice the carburizing of the base metal as a preparation for receiving rod metal is accomplished by the oxyacetylene flame properly adjusted and manipulated. The flame having a slight excess of an acetylene is the one generally used, because it facilitates the operation without unduly carburizing the weld. The one indispensable characteristic of the method is the formation of the carbonaceous film as a flux to enable the filler metal to unite with the base metal. Some information on the physical properties of the weld is given in the original article, and it is stated that this type of weld is particularly responsive to heat treatment, as illustrated by reference to butt welds in chrome-molybdenum aircraft steel. Successful welds with the new process have been made on chrome-molybdenum tubing having a wall thickness of only 0.020 in. (H. S. George, Research Engr., Union Carbide and Carbon Research Laboratories, Inc., in a paper before the American Welding Society, April, 1932; abstracted through *Journal of the American Welding Society*, vol. 11, no. 7, July, 1932, pp. 22–28, 9 figs., *dp*)

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer.

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AERONAUTICAL ENGINEERING

Engine Cowl Rings

THE radial air-cooled engine is a popular power plant. Its reputation with the public can be said to date from the summer of 1927, when it demonstrated its reliability and ruggedness in the hazardous long-distance flights of that year. Since then many refinements and improvements have been brought forth, but the drag of the radial engine has always been high. Large frontal areas are inherent with the radial engine, and as the power output of the present radial has increased, so has its frontal area. Until recently it did not seem likely that the radial engine could ever successfully compete with the liquid-cooled type as the power plant for use in high-speed airplanes. However, with the development of the N.A.C.A. type of cowling and the engine cowl ring by various aerodynamical laboratories, the big gap existing in actual ship's performance between these two widely divergent power plants has been eliminated. (Paper No. AER-54-12, by Paul M. Boyd.)

Engine Ring Cowlings

FAIRING of engines, either with the N.A.C.A. or the Townend type of rings, is becoming more and more the general practice with newly designed or revamped planes. There is a possibility of higher speed without increase of power, combined with a reduction of operating cost. The author points out the differences in the two types of cowling, and gives a description of test results and construction and suggestions for new experiments. Latest changes on several engines show accessories that affect installation of ring cowlings. (Paper No. AER-54-13, by W. H. Evers.)

Some Effects of Corrosion Fatigue on Streamline Wire for Aircraft

SEVERAL years ago aircraft designers began using what is commonly known now as "streamline wire" in the construction of tension members of aircraft. Wires of approximately elliptical section were adopted for the purpose of reducing parasite resistance. These wires are subjected to vibrations of varying frequencies, believed to be mainly of the torsional type. They are also under a pure tension stress when the plane is in dead air or on the ground. In addition to the aforementioned stresses, the wires are always subject to the very deleterious effects of corrosion. Corrosion, obviously, is a serious factor where naval or sea planes are concerned. Some effects of the combination of these conditions are discussed in this paper, in which the author presents data thus far obtained in an investigation at the Engineering Experiment Station, Annapolis, Md. (Paper No. AER-54-14, by Hugh E. Haven.)

Some Design Factors Which Influence Aviation Insurance Rates

FIVE principal factors which insurance underwriters consider when they are asked to estimate aviation hazards are: (1) the aircraft itself, (2) operational management, (3) the pilot, (4) the geographical limits, and (5) the uses for which the aircraft will be insured. The relative importance of these factors depends on the coverage being considered, and the connection of various aircraft design factors with these coverages is set forth. (Paper No. AER-54-15, by Jerome Lederer.)

Stresses in Rigid Airships: The Effect of Indeterminateness on Their True Value

PART I of the paper discusses statical determination as applied to a rigid airship and cites the difficulty of computing the actual stresses in a redundant structure of high degree. Part II treats the subject of statical stresses in an unbraced shell of varying longitudinal profile, advancing from a simple prismatic tube, through such a tube with a conical nose, to a symmetrical form of elliptical profile. Part III deals, in the way of a progress report, of the effect of introducing internal bracing, beginning with a single wire in a complete shell, prismatic or curved, and leading up to a more complex system in two prismatic bays.

The conclusions tentatively show that unless there is a considerable degree of rigidity in the bracing systems the shell stresses cannot be determined with even fair accuracy; that the change to loose wired ring frames requires careful attention to stresses induced in the shell by reason of the lowered rigidity of the ring frames as compared with tight wired frames; that there should be local reinforcement of members near concentrations of load; that keels and corridors have a marked influence on the stress distribution in the shell and that their effect on these stresses is as yet undetermined; that ships of curved profile differ so from those of prismatic form, heretofore studied, that the approach to Saint-Venant's principle is different and probably less certain; that there is some similarity to the stresses in a semi-rigid; that redundancy of the crossed diagonals in the facets of the shell is of rather localized effect; that even joint rigidity causes a secondary effect that is of importance; that some points are deserving of further study, such as the "keel effect" adjacent to loaded longitudinals; and the rigidity of the longitudinals between main frames; that there is evidence of a stress system underrunning the systems calculated by the common theories; that as the number of sides of the ship increases, from triangular to rectangular (square), hexagonal and octagonal, the stresses agree less and less well with the common theories, progressively, and since the trend is large, the effect should be studied further; that further study

is needed to determine if, and how much, additional braced frames reduce the discrepancy just noted; finally, attention is called to the fact that the discrepancies discussed apply only to part of the stress in any one member, and that the discrepancy from the total stress will be a lesser percentage. (Paper No. AER-54-16, by W. Walters Pagon.)

Special Methods of Testing Aircraft Materials

HEREIN is presented a study of special methods employed at Wright Field in the mechanical testing of characteristic aircraft materials and construction, together with a practical exposition of the special equipment developed. The testing of welded joints, riveted joints and fittings, and of parts such as axles, wheels, and brakes has been discussed, together with the combined loading of struts, columns, and beams. The proportional loading of wing ribs, the elimination of low-strength steel tubes, the reverse bending of streamline wires, the superiority of preformed cable, the determination of an economic pulley-cable diameter ratio, and the fatigue testing of streamline wires and of extra-flexible control cable are taken up in detail. The advisability of testing aircraft-engine materials over the temperature ranges to which they are subject in service is emphasized by the tension and Brinell results obtained on typical light piston alloys. The importance of simulating service conditions, especially in all tests involving endurance in any form, is heavily stressed. (Paper No. AER-54-17, by David M. Warner.)

IRON AND STEEL

Use of Blast-Furnace Gas in Soaking Pits

SOAKING pits as used today should be called "ingot-heating furnaces." Heat is applied from the fuel consumed to increase the temperature of the ingot in place of heat from the inner portion of the ingot flowing to the outer and colder parts. The surrounding atmosphere should be non-oxidizing and also not too much above the temperature to which the ingot is to be heated. An ideal fuel for this service is a low-Btu fuel such as blast-furnace gas. This paper gives results obtained by the pioneers in the use of blast-furnace gas in soaking pits, along with drawings of soaking pits that are successfully using blast-furnace gas as fuel. (Paper by G. T. Hollett.)

MANAGEMENT

The Engineer's Interest in Foreman Training

FOREMAN training in the United States was first adopted on a large scale about the time the nation entered the World War. Its success and its usefulness insure its continuance as an important factor in industrial management and in adult education. There is need, however, that educators, engineers, and industrial managers join forces to bring about better cooperation, broader understanding of the problems involved, and something resembling agreement as to purpose and methods. Some of the means by which cooperation may be furthered are: (1) There should be a clearer recognition of the importance of the foreman's position and his responsibilities in the organization. (2) Selection of employees for foremanship should be made carefully and with the aid of whatever scientific methods are available. (3) Employers should seek to understand the purposes behind foreman training, in order more intelligently to select methods suited to their needs. (4) Attempts should be made to agree upon the principles underlying foreman training and to eliminate the widest diversities in methods. (5) A national association for foreman training should be organized. (6) Engineering courses should be broadened to include more instruction in economics, business management, and labor problems. (Paper by E. S. Cowdrick.)

MACHINE-SHOP PRACTICE

Malleable Iron as a Component Part of Machines and Structures

MALLEABLE cast iron as a dependable engineering material is due to comparatively recent research. Size restrictions and competitive materials are considered in the paper, and the properties of malleable iron and its machinability are treated. Its suitability and its relative importance as a component part of various machines and apparatus are discussed, followed by illustration of its wearability. (Paper by Enrique Touceda.)

MATERIALS HANDLING

Factors Affecting Shipping Other Than the Cost o Transportation

SOME pertinent factors, other than transportation rates, that affect shipping are presented. The railroad investment of some 26 billion dollars depends for returns on the ability to carry a sufficient tonnage of goods at a profit; and as this is predicated on the ability to give the shippers a more economical service than that of competitors, railroad management must attack the problem of the other factors that predominate over mere rail rates in affecting the decision of shippers. The expansion of container methods of shipment and the door-to-door pick-up and delivery plan make it advisable for the railroads to begin at once a study of the problem of container interchangeability and of the general problem of materials handling. The railroads have made marked progress in the methods of handling their own stores, with a resultant reduction of nearly 400 million dollars in inventory investment. In the utilization of modern handling methods in the revenue-producing classifications of freight, there remains a correspondingly great opportunity for economies. A complete study by materials-handling engineers for the railroad system of the country as a whole is suggested. (Paper by M. W. Potts and J. A. Cronin.)

OIL AND GAS POWER

Diesels for Small Boats

MOTOR vessels of the smaller types, excluding ships in ocean service, form the subject of this paper, which states how such vessels are employed, where they are built and operated, and gives in comprehensive form an impression of the machinery requirements in various services. It discusses the machinery requirements peculiar to different marine services such as fishing, towing, freighting, passenger transportation, ferryboat operation, tanker service, and yachting, and states in general terms the demands imposed upon the Diesel engines found in these several boat types. Stress is laid upon the important influence which yachting has exerted on Diesel development. The use of Diesels in some 2915 American motor vessels with about 1,131,200 hp is stated as showing the volume of such work that has been completed in this country. (Paper by A. B. Newell.)

CORRESPONDENCE

READERS are asked to make the fullest use of this department of "Mechanical Engineering." Contributions particularly welcomed at all times are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on its activities or policies in Research and Standardization.

Solid-Friction Damping

To the Editor:

In Vol. 51 of the A.S.M.E. Transactions, paper APM-51-21, pages 230 and 231, the discussion of A. L. Kimball's paper on solid friction damping by J. P. Den Hartog contains a statement that does not agree with experimental evidence or with analytical reasoning. Speaking of vibration damping by internal solid friction where the energy loss per cycle is proportional to the square of the stress amplitude, Mr. Den Hartog says: "The title of the paper might give rise to the misunderstanding that this method also covers cases where damping is caused by solid friction between dry surfaces, *like leaf springs*, certain types of automobile snubbers, etc. This is apparently not so. . . ."

When dealing with cases of dry friction between surfaces where the normal force causing the friction is constant, this statement is correct. However, in the case of leaf springs, the normal force causing the friction is proportional to the applied load, as are also the deflection of the spring and the relative motion between the leaves. Thus, the friction force is proportional to the load applied, and the distance through which this force acts is proportional to the load, making the frictional energy proportional to the square of the load. This reasoning classes the damping of leaf springs with other cases of damping where the energy loss per cycle is proportional to the square of the stress amplitude.

This reasoning is borne out by tests of actual springs. Fig. 1 shows the experimental damping loops for an automobile spring having a master leaf 2 in. wide and $^5/_{16}$ in. thick, and 7 auxiliary leaves ranging from $^5/_{16}$ in. to $^1/_4$ in. in thickness. The unloaded span of the spring is 54 in., and the unloaded camber at the center is $6^1/_4$ in.

In Fig. 2, the integrated energy losses per cycle are shown plotted against loads, and it is evident that the resulting curve is not a straight line.

The same energy losses per cycle are shown plotted against the square of the applied load in Fig. 3. Since this curve is definitely a straight line, the reasoning previously set forth is borne out. It therefore seems safe to say that, contrary to the statement in the reference given, the energy loss per cycle in leaf springs is proportional to the square of the stress amplitude, and is of the same form as for internal solid damping, even though the losses are caused by dry sliding friction.

Neil P. Bailey.[1]

Chapel Hill, N. C.

To the Editor:

Professor Bailey shows that the vibration of a simple system consisting of a leaf spring and a mass at its end has an energy dissipation which is proportional to the square of the amplitude of vibration and consequently can be made amenable to the usual analysis applied to vibration cases. This is perfectly correct for the case treated by Professor Bailey, where the deflections during vibration either extend to both sides of the equilibrium position or to one side only, but at least the amplitude has to come back to zero each time during the cycle. The tests made by Professor Bailey pertain to this case.

The situation with leaf springs in an automobile, however, is somewhat different. Here there is a considerable load acting on the spring whether there is vibration or not, and small vibrations about this *loaded* equilibrium position will hardly change the pressure between the leaves. When this is the case, the pressure between the leaves, and consequently the friction force, can be considered nearly constant, so that the energy dissipation is proportional to the first power of the amplitude only. In cases of this type (which the writer had in mind in making the remark in the discussion referred to) it is clear that the analysis given in Mr. Kimball's paper does not apply.

J. P. Den Hartog.[2]

Cambridge, Mass.

Metallurgy in the Railroad Field

To the Editor:

In a paper[3] presented by Prof. A. E. White at the Birmingham meeting of the A.S.M.E. the following passage occurs, to which the writer takes exception:

> Car wheels originally were made of cast iron. This practice led to many failures accompanied by derailment as the size and weight of the equipment increased. For the most part, cast-iron wheels are not used on equipment when the weight is over 70 tons. Rolled steel wheels are generally used on all freight cars of over 70 tons, on all passenger cars, and on all locomotives and tenders, except for the driving wheels and the large-sized trailing wheels. Because of the gradual displacement of cast-iron wheels by steel wheels there has been a material decrease in derailments. The railroad engineers are therefore recognizing that, in general, failures due to wheels are no longer a source of serious importance.

The word "originally" in the first sentence of this quotation indicates that a change has been made in some period of railroad history. Railway statistics taken from the Interstate Commerce Commission's reports, from the annual reports of the United States Steel Corporation, and from the records of the Association of Manufacturers of Chilled Car Wheels, indicate a fairly constant relationship between the number of chilled-iron wheels shipped and the billions of ton-miles of freight lading handled by the railroads, showing that there

[1] Associate-Professor of Mechanical Engineering, University of North Carolina. Assoc-Mem. A.S.M.E.

[2] Assistant Professor of Applied Mechanics, Harvard Engineering School, Harvard University. Assoc-Mem. A.S.M.E.

[3] "Metallurgy in the Railroad Field," by A. E. White, Trans. A.S.M.E., vol. 53 (1931), paper RR-53-2.

has been no falling off in the number of chilled wheels, but that they have kept pace with the increase in tonnage hauled.

From 1895 to 1929 the freight ton-miles increased 400 per cent, and the number of chilled-iron wheels increased in like proportion. The rolled steel wheels have taken the place of the steel-tired wheel in passenger and engine-tender service, reaching full production in 1909. The relationship between the tons of steel wheels made by the United States Steel Corporation and the combined locomotive and passenger car-mileage is fairly constant. The average miles per ton made is almost the same in the first 10 years as in the second 10-year period. If there had been any large substitution of steel wheels for the chilled-iron wheels these ratios would be disturbed. These statistics do not indicate that the chilled-iron wheel has lost its supremacy, but that it stands higher than ever today due to the constant improvement that has been made in its design and the process of manufacture.

A complete check of freight cars in the United States and Canada in 1927 showed that there were 2,741,600 cars below 70 tons capacity and 157,500 cars of 70 tons capacity and over. This indicates that only 5.4 per cent of the freight-car mileage is performed by cars of 70 tons capacity and over, and therefore they can be disregarded in this discussion.

In the last normal year of car building there were built 65,702 cars equipped with chilled-tread wheels, and 11,191 cars equipped with steel wheels, multiple-wear, single-wear, and cast steel, below 70 tons capacity; and of the 11,191 cars equipped with steel wheels, approximately one-half of them were for the Pennsylvania Railroad and subsidiary lines which, on account of their intimate relationship with the steel corporations, have used steel wheels for the past twenty-five years. The other half was made up largely of experimental lots of single-wear wheels for the economic reason of a very great reduction in price per wheel.

Here again there is no indication of any falling-off in the use of chilled wheels under the great burden of railway freight traffic; hence the freedom from derailment as indicated cannot be attributed to the elimination of the chilled-tread car wheels.

The second sentence of the quotation reads:

> This practice led to many failures accompanied by derailment as the size and weight of equipment increased.

If the Interstate Commerce Commission's reports of derailments are analyzed with care it will be found that in the 30-ton class the expectancy of a broken wheel is one for each 192,000,000 wheel-miles, whereas under the 50-ton car the expectancy of a broken wheel is about one for each 500,000,000 wheel-miles. In the 70-ton-capacity cars there have been no derailments on account of chilled-iron-wheel failures during the fifteen years since the 70-ton car has been in existence, while many steel wheels have broken in the same service.

Another sentence that requires analysis is:

> Rolled steel wheels are generally used on all freight cars of over 70 tons, on all passenger cars, and on all locomotives and tenders except for the driving wheels and the large-size trailer wheels.

This positive statement does not accord with the facts in the case. For sixty years the Illinois Central Railroad used chilled-iron wheels in their suburban service, carrying 15,000,000 passengers per year without a broken wheel in all this period. The same is true in the service of other railroads. At the present time a certain railroad is operating its "Fliers" in interstate traffic with chilled-iron wheels from the drivers on the engine to the Pullman cars. Certain railroads have discarded steel wheels in their engine-tender service and have used chilled-iron wheels throughout.

Let us look into the last statement in the quotation from the paper:

> The railroad engineers are therefore recognizing that, in general, failures due to wheels are no longer of serious importance.

If inquiry should be made of the mechanical engineers of our large railroads they would tell a story that would not quite line up with this conclusion, because of the more severe service which is constantly imposing greater demands on all kinds of railway car wheels.

Engineers have a long way to go in their study of cause and effect, which, when completed, will lead to the manufacture of more serviceable material to meet these ever-increasing demands.

F. K. VIAL.[4]

Chicago, Ill.

Credit Control vs. Overinvestment

TO THE EDITOR:

The article by Mr. Ralph E. Flanders in the November, 1932, issue of MECHANICAL ENGINEERING, offers a most illuminating brief critical analysis of some of the engineering thought being devoted to the problems of national economics.

One concept apparently not included in this analysis which has been brought out, perhaps rather inadequately, in an unpublished paper by the writer, a summary of which has been distributed by the Engineering Foundation, is as follows:

a The important business cycles are the result of serious unbalance between the element of "capital" or finance, as per Coyle, and business, following the general concept of several recent writers.

b The equilibrium between these two factors, capital and business, is an unstable one. This instability is of a definite cumulative character, and a departure in the direction of inflation takes place as an exponential function of time or of business transacted.

c The factor which introduces the instability is the occurrence of an unearned increment to capital; in fact, a strictly unearned increment over and above any normally expected increase in earnings.

d When an inflation has progressed to a certain extent, the economic forces set up through accumulation of this unearned increment so dominate the situation as to relegate other forces to a secondary place. Some of these, like credit expansion, intensify the inflation; others, such as increased distribution and use of consumables, work in the opposite direction. But all are dominated by the major factor of expansion in quoted values of capital.

e The factor of instability can be controlled or "damped out" by the immediate diversion of a definite percentage of the unearned increment of capital to consumables or to social capital at the start of a period of capital inflation.

f A careful statistical analysis of the trend of actual national earnings as compared with a comprehensive index of quoted values of capital (of all kinds) might be used to detect an incipient inflation and permit the damping factor to be applied in advance of any important departure from equilibrium.

g This concept seems to avoid some of the conflicts in thought pointed out in Mr. Flanders' article, and at the same time proposes a means of introducing the stabilization required for maximum industrial progress, with a ***minimum*** disturbance of the existing social and economic system.

[4] Consulting Engineer, Association of Manufacturers of Chilled Car Wheels.

The discussion is presented here, however, as a basis for an entirely different line of thought. Many engineers and some economists at the present time are thinking and writing along lines which promise an eventual solution of the stupendous problem of economic control. There is general fear that the world may have escaped by a narrow margin such a catastrophe as engulfed Europe during the dark ages, and that we may not yet be far from the brink of another such era.

In the meantime there is, among the "practical" bankers, business men, and politicians, a growing impatience toward high-strung theories and questionable schemes for improving conditions, under which head even the best of our efforts as engineers are still likely to be classed. As a result each book or article by an engineer or scholastic economist setting forth some phase of the economic problems is likely to add to the "sales resistance" of the practical men in power toward the "new economics."

I wish to urge, therefore, that the engineers of the country and the interested economists immediately work out a plan for correlating the many budding ideas, as yet incomplete, into a systematic and logical plan for effective economic readjustment.

Such a final "philosophy of economics" must be scientifically and logically sound; correct from both the economic and social sides, and must offer a minimum disturbance of accepted conditions. It must be presented so forcibly and with such unanimity among engineers and economists as to escape the criticism of being "just one more scheme." Political leaders at least are now in a frame of mind to consider any proposal which shows convincing evidence of the above characteristics.

I am satisfied that this can be done.

H. C. DICKINSON.[5]

Washington, D. C.

Control of Operating Expenses

TO THE EDITOR:

The conception of a linear relation between cost and output, which has been examined in Professor Livingston's article in the October issue of MECHANICAL ENGINEERING, provides an exceedingly useful tool, partly because its simplicity greatly facilitates the solution of problems involving comparisons of costs under various conditions, and partly because its form is convenient for use in making rate studies and other economic investigations. Its value to engineers will be increased and perhaps more generally appreciated as knowledge of its possibilities and limitations is accumulated. This article contributes two important "possibilities," a test for significance and a mathematically established control band, but does the subject no favor by discounting its limitations.

No fault can be found with the author's defense of the method of least squares, and his Fig. 3 may permit greater assurance in application of this method when the number of observations are limited. This is the test for significance, adapted from R. A. Fisher. Use of a control band is exemplified by his Fig. 5. Study of this plot prompts the thought that this control band of uniform width provides a more logical tolerance than the usual allowance of a fixed percentage, though this perhaps depends to some extent on the way in which the costs were originally determined, i.e., whether a large mechanical error of fixed percentage was introduced.

The least satisfactory section of the article is that dealing with the choice of the functional form in fitting curves to a collection of data. Its importance is admitted—"It is in this first part where the majority of trouble occurs"—and the author obviously appreciates the limitations of the straight-line equations when applied to "a broad space of variation of both factors," which makes it difficult to understand his reasons for concluding that "except in an unusual or special case the use of a second-degree, a discontinuous, or a broken curve is seldom warranted." Operating engineers are more likely to believe that it is only the special case which shows a straight-line relation over any considerable range, and can produce a wealth of data to support the contention.

Power-plant costs analyzed in this paper show marginal costs of 3.11 mills per kwhr. Further analysis would prove this to be preponderantly a fuel cost. Now in most plants the marginal fuel rate at full load is much greater than the marginal rate at 13 per cent load (the average plant factor in the author's example); studies made by the writer's company show about double the light-load rate near full load for its stations. A block of on-peak load then might readily have a marginal cost of 5 mills instead of 3.11 mills, which means that a daily increase of 30,000 kwhr during the peak period would give total monthly costs outside the established control band. A similar load acquired during the light-load periods at night might result in an equal error in the opposite direction. This illustrates the effect of variations in load characteristics which make up the total kilowatt-hours, combined with the fact that the hourly input-output lines of neither turbines nor boilers are perfectly straight lines.

Another example is provided by a study recently made of Diesel-engine fuel rates. Annual fuel consumption plotted against output over a period of three or four years for about twenty different plants showed a high degree of correlation. All of the two-cycle plants appeared to have a very constant marginal fuel rate, and another rate was equally suitable for all four-cycle plants. The same value checked well with monthly figures obtained from one plant over a two-year period. Theoretical considerations led to mistrust of this simple solution, however, and it was later discovered that the good results could be accounted for in large measure by the accidental variation of engine-hours directly with the kilowatt-hours in the cases examined.

The moral of this discourse is that the scatter of points about a straight line should not be too lightly ascribed to chance when analysis of the data indicates that certain conditions force a departure from straight-line behavior. Definition of these conditions is often very simple. For instance, the annual fuel consumption of a steam power plant in a utility system can often be estimated with great accuracy by a single linear equation, provided the output is within certain limits of capacity factor. Here the limitations to *annual* figures and to range of output are sufficient to describe a quite definite cycle of load characteristics. As a general rule one formula will be found to apply for annual outputs of from 40 per cent to 60 per cent, another from about 15 per cent to 40 per cent, and a third above 60 per cent. Monthly figures may be estimated with less accuracy, and at very low output other definitions of the load besides capacity factor are essential.

Such limitations of the straight-line formula do not impair the value of the procedure outlined by the author if they are thoroughly understood. Probably he deliberately omitted discussion of them for lack of space, but his methods are apt to be dismissed as being impractical because this important consideration appears to have been slighted.

PAUL H. JEYNES.[6]

Newark, N. J.

[5] Chief, Heat and Power Division, Bureau of Standards.

[6] Engineer, Public Service Electric and Gas Co.

RESEARCH—STANDARDIZATION—CODIFICATION

Notes on Work of Technical Committees of the A.S.M.E., Etc.

Research

Boiler-Feedwater Research

THE Joint Research Committee on Boiler Feedwater Studies is pleased to be able to report progress in its experimental investigations of priming and foaming, of methods for boiler-water analyses, and of the effect of sodium sulphate in inhibiting cracking of boiler steel. This Committee is sponsored by the A.B.M.A., A.R.E.A., A.W.W.A., N.E.L.A., A.S.T.M., and the A.S.M.E., and its personnel is made up of engineers concerned with boiler-water conditioning in central and industrial power stations and on railroads.

SODIUM SULPHATE SOLUBILITY STUDIES

It is generally agreed that sodium sulphate, in sufficient amounts in boiler-water salines, inhibits cracking of boiler steel, as may be effected by high concentrations of caustic soda. Definite knowledge concerning the mechanism of sodium sulphate film formation, and the effect of such film as an inhibiting agent, is not available. The Committee is undertaking a research program to secure additional fundamental data on this subject, since by the collection of such information more accurate control of boiler-water conditioning is possible. The proposed study will include certain phases of film formation not previously studied by other investigators, and is to secure data on this complex problem which will supplement the work of other investigators in this field.

Tentative arrangements have been made with the Bureau of Mines for the conduct of the work at its Non-Metallic Minerals Experiment Station in New Brunswick, N. J., under the direction of Dr. E. P. Partridge. The estimated budget is $7500 a year for two years, and half this fund has already been contributed by industry. The program will be directed by a subcommittee of which J. H. Walker, Detroit Edison Co., is chairman, T. E. Purcell, Duquesne Light Co., vice-chairman, and A. D. Bailey, Commonwealth Edison Co.; R. E. Hall, Hall Laboratories; E. B. Powell, Stone & Webster; J. B. Romer, Babcock and Wilcox; and D. B. Keyes, University of Illinois, are members.

BOILER-WATER ANALYSES

That our present standards of analytical procedures for boiler-water analyses are wholly inadequate has been revealed by the critical studies made for the Joint Committee at the University of Michigan under a research fellowship the committee has financed there for the past two years. Reports on the determination of carbonates, hydroxides, and phosphates in boiler waters have been issued. Copies may be obtained from C. B. LePage, assistant secretary, The American Society of Mechanical Engineers, for a nominal price. A report on determination of sulphates will shortly be released. Further work on the determination of dissolved oxygen present in waters, in small quantities, will be undertaken since there are apparent inaccuracies in the recognized method now in use. It is planned to have a tentative standard method developed and ready for discussion by June, 1933.

These studies have been supervised by a subcommittee under the chairmanship of C. H. Fellows, of the Detroit Edison Co. This subcommittee is working in close cooperation with Committee D-19 of the A.S.T.M. which was formed recently for the standardization of water analysis for industrial use.

PRIMING AND FOAMING

The third experimental investigation which the committee is supporting is on the priming and foaming of boiler waters under the direction of Prof. C. W. Foulk at Ohio State University. The first progress report was published in MECHANICAL ENGINEERING for November, 1931, and a subsequent one will be released in the near future.

The two investigations now in progress have cost nearly $5000 to date. Continuation of this work during the business depression has been made possible chiefly by the financial support of the Engineering Foundation, amounting to $3000 during 1932, with some further aid promised for 1933. The Foundation very properly points out, however, that the committee's program is of direct benefit to industry and should be financed by it. It is confidently felt that this support will be forthcoming when business improves.

Standardization

Standard Abbreviations and Symbols for Scientific and Engineering Terms

AN AMERICAN Tentative Standard for Abbreviations for Scientific and Engineering Terms has been completed and approved by the sponsor organizations and the American Standards Association. While this standard of 287 abbreviations constitutes only a beginning of the process of unifying present practice in the use of shortened forms in technical and other types of literature, it can be said that the items on this list have already received the practically unanimous approval of those vitally interested. The list of abbreviations as published is prefaced by a set of rules recommended for the guidance of authors.

The task of setting up a list of abbreviations was included within the scope of the Sectional Committee on Scientific and Engineering Symbols and Abbreviations which was organized in January, 1926, with the S.P.E.E., A.S.C.E., A.A.A.S., A.I.E.E., and A.S.M.E. as joint sponsors under the procedure of the A.S.A. George A. Stetson is chairman of the Subcommittee on Abbreviations which developed the original proposal. The other members of his committee are G. F. Bateman, S. McK. Gray, W. T. Magruder, W. N. P. Reed, and H. E. Ruggles.

In the preparation of this standard the earlier recommendation of the International Committee on Weights and Measures to omit the period in abbreviations of metric units has been carried one step farther, and in the interests of economy and the reduction of waste the elimination of the period is recommended except where such an omission results in an English

word. Thus "cif" should be used as the abbreviation for cost, insurance and freight, not "c.i f." On the other hand, "f.o.b." is retained since "fob" is a well-known word. Again, while "feet" may be abbreviated to "ft," "inches" should be written as "in.," since "in" is a common preposition. Exceptions to this practice will be found in a few mathematical and chemical terms, such as sin, tan, log, As, Be, etc.

As stated above, this project is part of a larger one which includes letter symbols and graphical symbols. Committee work on the standardization of the symbol side of nomenclature began back in July, 1917, with the appointment of a joint S.P.E.E.-A.S.M.E. committee to investigate the possibility of standardizing technical symbols and abbreviations. The activities of this joint committee led to a conference on technical symbols which was held in New York on December 2, 1918, where representatives of the S.P.E.E., A.S.C.E., A.I.E.E., S.A.E., A.I.M.E., and A.S.M.E. were present. This conference encouraged the Joint Committee to proceed with its work and approved the list of symbols for mechanics and hydraulics which had been prepared by a committee of the S.P.E.E. and approved by that society in June, 1918. This Committee's report was published in the October, 1918, issue of MECHANICAL ENGINEERING. The A.S.M.E. Committee on Nomenclature had published a progress report in December, 1914, as its Transactions paper No. 1054. This was followed by another report presented at the meeting in Chicago in May, 1921. The S.P.E.E. report of 1918 was followed in 1923 by a suggested list of letter symbols for heat and thermodynamics published in *Engineering Education* for November, 1923. The records of this early activity bear testimony to the patient, persistent pioneer work of Messrs. John T. Faig and Sanford A. Moss.

The early drafts of the A.S.M.E. Power Test Codes publication known as "Definitions and Values," beginning March, 1921, prepared by a Committee for which R. J. S. Pigott is chairman, included a list of letter symbols for terms used in thermodynamics. In the successive drafts of this report the list of symbols grew until July, 1924, when the Council of the Society appointed a special committee to review this list before publication pending the setting up of an American Standard under the procedure of the American Standards Association.

Realizing that the broader development of this project would be accomplished best if it became part of the national standardizing movement, in December, 1922, the A.S.M.E. addressed a letter to the American Standards Association requesting the approval of this project and the organization of a representative sectional committee. This request was received with favor and a preliminary conference was held on February 13, 1923. This conference approved the project and recommended the appointment of a special committee to prepare recommendations for the wording of the scope and the organizations to be named as sponsor. The S.P.E.E., A.S.C.E., A.A.A.S., A.I.E.E., and A.S.M.E. were finally named as sponsor bodies, and the first meeting of the Sectional Committee was held on January 21, 1926. The personnel of this committee now includes official representatives of 37 societies and associations having a national status.

At the organization meeting and since, the committee's task was divided among nine subcommittees, and to date standard lists of letter symbols have been completed and approved for the following subjects: mathematics, electrical quantities, aeronautics, hydraulics, photometry and illumination, heat and thermodynamics, and mechanics, structural engineering, and testing materials. In addition standard sets of graphical symbols have been completed for telephone and telegraph use, electric power, electrical-supply materials, radio communication, and traction and signaling. This committee has been fortunate in having Dr. J. F. Meyer for its chairman and P. S. Millar for its secretary. In addition to these gentlemen, the executive committee includes Dr. Sanford A. Moss, vice-chairman, and Prof. Charles M. Spofford, Dr. Arthur E. Kennelly, and Dr. Harvey N. Davis.

The activities of this Sectional Committee and the I.E.C. Advisory Committee on Steam Turbines have stimulated the I.E.C. Advisory Committee on Nomenclature to revise and enlarge its report completed, approved, and published in January, 1914, to include a set of international letter symbols. The United States National Committee of the International Electrotechnical Commission holds the secretariat for this advisory committee, and Dr. Harold Pender is the associate director in charge of the Section on International Standards for Letter Symbols.

New Standards

GEAR MATERIALS AND BLANKS

A RECOMMENDED Practice for Gear Materials and Blanks has just been submitted to the American Standards Association for approval. This standard practice was developed by the Sectional Committee on the Standardization of Gears organized in June, 1921, and sponsored by the American Gear Association and The American Society of Mechanical Engineers. The proposed standard is divided into four parts: (1) forged and rolled carbon steel, (2) steel castings, (3) bronze and brass castings, and (4) forged and rolled alloy steel. Each of these sections includes chapters on general specifications, manufacture, ladle and check analyses, finish, marking, inspection, rejection, and reheating. Tables on chemical composition are also included for each type of material.

T. D. Lynch, formerly consulting metallurgical engineer of the Westinghouse Electric and Manufacturing Company, served as chairman of the subcommittee during the development of the standard, and the other members of the subcommittee were Messrs. J. J. Boax, chief engineer, National Tube Co., McKeesport, Pa., L. H. Fry, metallurgical engineer, Edgewater Steel Co., Pittsburgh, Pa., C. B. Hamilton, Jr., president, Hamilton Gear and Machine Co., Toronto, Ontario, Canada, E. F. Kenney, metallurgical engineer, Bethlehem Steel Co., Bethlehem, Pa., and E. C. Smith, assistant superintendent, Central Alloys Steel Corp., Massillon, Ohio.

This is the second standard developed by this sectional committee to be approved by the A.S.A., the other being "Spur-Gear Tooth Form, $14^1/_2$-Deg Composite System, $14^1/_2$-Deg Full-Depth Involute System, 20-Deg Full-Depth Involute System, and 20-Deg Stub Involute System."

SHAFTING AND STOCK KEYS

A new proposed standards pamphlet entitled "American Standard for Shafting and Stock Keys" is a compilation and revision of four standards on this subject previously approved by the A.S.A. It combines Cold-Finished Shafting Diameters (1924), Square and Flat Stock Keys (1925), Plain Taper Stock Keys (1927), and Gib-Head Taper Stock Keys (1927). The Committee found it necessary to revise and extend these four standards at this time, and it was decided to combine and publish them under one cover with introductory notes for finished shafting, plain parallel stock keys, plain and gib-head taper stock keys, and tolerances on key and shafting dimensions. The Committee began this revision approximately three years ago, and has now completed it to the satisfaction of both the consumer and user groups. The American Society of Mechanical Engineers is sole sponsor for this project. The Sectional

Committee on the Standardization of Shafting, organized in October, 1918, under the chairmanship of Cloyd M. Chapman, has presented two other standards to the A.S.A. for approval, i.e., "Woodruff Keys, Cutting Slots and Cutters," approved in 1930, and the "Code for the Design of Transmission Shafting," approved in 1927.

Copies of these two new standards may be obtained on request to the A.S.M.E., 29 West 39th Street, New York, N. Y.

A.S.M.E. Boiler Code

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Below are given records of the interpretation of the Committee in Cases Nos. 733, 734, and 737 to 745, inclusive, as formulated at the meeting of December 9, 1932, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

CASE No. 733

(Annulled)

CASE No. 734

Inquiry: When a jacketed vessel is under consideration and the interior chamber is not subject to pressure, does the volume V in the formula in revised Par. U-1 refer to the jacket volume only, or to both the jacket and the interior chamber of the vessel?

Reply: It is the opinion of the Committee that when the interior chamber of a jacketed pressure vessel is open and not subject to pressure, the factor V applies only to the jacket. When both the interior chamber and the jacket are subject to pressure, the factor V applies to the entire volume of the vessel.

CASE No. 737

Inquiry: Is it necessary, in applying the rules of the Code to pressure vessels, to consider that the exemption in Par. U-1 of the Code applies to the working pressure up to the setting of the safety or relief valves; or must the static head that may result in any part of the vessel by contained liquid be included?

Reply: It is the opinion of the Committee that the pressure referred to in Par. U-1 is that on which the safety-valve setting is based and not that resulting in certain parts of the vessel by possible static head. The Code provides limiting stresses for use in the design of pressure vessels, and it is necessary to take account of the effect of static head that may be produced in any part in order that such stress limits be not exceeded.

CASE No. 738

Inquiry: Do the exemptions in Par. U-1 of the Code apply to single vessels only, or to assembly of vessels in a system?

Reply: It is the opinion of the Committee that the exemptions apply to each single vessel and not to an assembly of vessels.

CASE No. 739

Inquiry: Par. U-70 of the Code states that Class 3 vessels may be used for the storage of gases or liquids at temperatures not materially exceeding their boiling temperature at atmospheric pressure and at pressures not to exceed 200 lb per sq in., and/or not to exceed a temperature of 250 F. In the case of water and steam, what is the maximum temperature at which Class 3 vessels may be used?

Reply: It is the opinion of the Committee that the maximum temperature that should be applied to water and steam in interpreting Par. U-70 is 250 F, which corresponds with the temperature of steam at a pressure of 15 lb per sq in. above the atmosphere, which is the maximum allowed in steam-heating boilers.

CASE No. 740

(In the hands of the Committee)

CASE No. 741

Inquiry: Pars. H-55 and H-108 of the Code require each steam gage to be connected to the boiler by means of a siphon or equivalent device exterior to the boiler. Will a steam gage meet these requirements if the siphon is incorporated within the gage casing?

Reply: It is the opinion of the Committee that the location of the siphon inside of the steam-gage casing will not conflict with the requirements of the Code, provided it is of sufficient capacity to keep the gage tube filled with water and there is visible evidence of the presence of the siphon in the gage casing.

CASE No. 742

(In the hands of the Committee)

CASE No. 743

Inquiry: Is it permissible, under the requirements of Par. U-71 of the Code, to use pipe material conforming to Specifications S-18 of the Code to form the shells of pressure vessels, to the ends of which heads of plate material conforming to Specifications S-2 will be attached by forge welding?

Reply: It is the opinion of the Committee that lap-welded, open-hearth pipe, or low-carbon seamless pipe under Specifications S-18, may be used for the construction of forge-welded vessels under the rules of the Code.

CASE No. 744

Inquiry: Is it permissible, under Par. U-96 of the Code, to apply or insert heads in ends of shells by shrink fits in place of driven fits when they are to be brazed?

Reply: It is the opinion of the Committee that the shrinking of the heads into the ends of the shells is the equivalent of drive fits.

CASE No. 745

(In the hands of the Committee)

BOOK REVIEWS AND LIBRARY NOTES

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. It is administered by the United Engineering Trustees, Inc., as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets, and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

Problems in Human Engineering

PROBLEMS IN HUMAN ENGINEERING. By F. Alexander Magoun, S.M., and his students. The Macmillan Company, New York, 1932. Cloth, $5^1/_4 \times 7^3/_4$ in., 535 pp., $2.60.

THERE must be a lot of zest in Professor Magoun's class in "Humanics" at M.I.T., solving on paper the ticklish problems in human relationships that are typical of what is in store for young graduates and listening to the solutions offered by one's equals in age and experience. His method of instruction in appropriate action would seem to mark an advance over that of the telling of the time-honored tale with its moral. There may be an unreality to such an academic approach to life's problems, solved not in the heat and impetuosity of the moment, but with time for reflection and detachment from the incidents and the consequences of improper action. But, on the other hand, the story of the shepherd boy David provides little practical help in time of stress. The sling, the five smooth stones from the conveniently placed brook, the menacing Goliath, and the sure, accurate aim, culminating in gory decapitation, the flush of victory, and a kingdom to worry about, are legendary and remote. A slight hitch in these well-ordered events and history would have taken another course. The struggle of right against might would have lacked a dramatic episode, Hebrew literature would have been less rich in poetry, Jonathan would not have become a symbol of devoted friendship, nor would Uriah be remembered today as the aggrieved apex of an "eternal triangle."

Modern Goliaths are slain by a different technique. The book of Samuel records an episode that turned out favorably for one of the actors in it. Professor Magoun's problems present perplexing situations in which action is demanded; and while the situations are said to have presented themselves in real life, the actions which they evoked are not stated. Instead, a variety of suggested actions are proposed by an equal number of men who have never been face to face with such disturbing realities, but who have pondered the fundamental principles involved.

Professor Magoun's book is one solution of the perplexing problem of how to teach young men to understand the subtleties and the importance of human relationships. It presents the method used by him at M.I.T. in his class in "Humanics." In conducting the class, a problem in human relationships is assigned after the fundamental principles involved have been freely discussed. The problems assigned present, in general, actual situations that have come to the instructor's attention, and each member of the class is required to prepare a written statement of what action he would take if placed in such a situation. At a later session a number of the solutions are read to the class. The book is devoted to the statement of fifty such situations and representative solutions offered by nearly 500 students and selected from well over 10,000 papers. There is little comment by the author and editor on the solutions.

The book makes entertaining reading and evokes a spirit of humility and uneasiness in the reader, who searches in vain both the book and his own mind for the "one best way" in which each of these fifty situations might have been met. Taken in conjunction with our American variety of the famous cricket-field training that has been such a valuable feature of British education, such a course as Professor Magoun conducts should be of great practical value to the young men who are subjected to it. It seems improbable that even the most obtuse would fail to develop a greater measure of understanding by such a method. Incidentally, Professor Magoun has an enviable facility at writing pithy captions.—G. A. S.

Hydrodynamics and Aerodynamics

HYDRO- UND AERODYNAMIK (Handbuch der Experimental Physik, Vol. IV), Edited by Professor L. Schiller, Leipzig. Part 2, Widerstand und Auftrieb (Resistance and Lift). Published by Akademische Verlagsgesellschaft m.b.H., Leipzig, 1932. Cloth, $6^3/_4 \times 9^1/_2$ in. viii + 443 pp., 245 figs., 41 marks.

REVIEWED BY STARR TRUSCOTT[1]

THIS is the second part of the fourth volume of the "Handbook of Experimental Physics." Parts one and three appeared last year and it was understood that the volume was to be completed with the issue of part two. However, the number of parts has been increased to four, and part four has just appeared.

The arrangement followed in this second part is the same as that followed in the previous parts. Each author discusses a subject without apparent effort to tie it to the others, either of this part or of the other parts of the volume. Yet, thanks to the manner in which it is done and to the editing and arrangement, each part is found to have good cohesion in itself and the whole has it to a surprising degree.

The present part, devoted to resistance and lift, is of especial interest to the naval architect and the aeronautical engineer.

[1] Aeronautical Engineer, National Advisory Committee for Aeronautics, Hampton, Va.

However it also includes a section on journal friction and lubrication which ties this subject into the hydrodynamic family.

The first section, of about 60 pages, by O. Flachsbart, of Göttingen, is entitled "The History of Experimental Hydro- and Aero- Mechanics, Especially Research on Resistance." In it we have first a rapid survey of the ideas regarding the resistance encountered by a body moving in a fluid as they appeared in antiquity and the middle ages. This starts with the Greek philosophers and carries through Leonardo da Vinci to the beginning of the method of systematic research about 1600 A.D. It is followed by the story, in considerably more detail, of the development of modern theories, modern methods, and equipment for research. It is studded thick with notable names, dates, and discoveries.

Taking up the study of hydrodynamic resistance, the author describes briefly the successive experiments, telling something of the apparatus, the methods, and the results, which built up the body of knowledge of this subject from 1600 A.D. on. Particular attention is paid to the development of devices for testing models in a way to simulate reality such as the naval tank or model testing basin, and the wind tunnel, although the emphasis appears to be placed on the latter.

The reading of this review of the history of one phase of engineering can be recommended to all interested in its fields. Dr. Flachsbart has accomplished a marvel of condensation, yet has preserved much in breadth and detail. The writer believes, however, that he might well have mentioned the work of Frederick Chapman, whose book on shipbuilding was first published in Sweden in 1775 and was issued in a French translation in 1779.

Chapman was deeply interested in the problem of resistance and in the work mentioned gives much space to methods for estimating it, including as well tables of values for different forms, obtained by towing models. He also gives very complete instructions for constructing and operating a towing basin.

In the second section, of about 45 pages, Dr. Prandtl discusses the great problem of the wind tunnel, namely, the production of uniform air flow. With characteristic simplicity and clarity he tells why and how the much-desired perfection of air flow through the wind tunnel is to be developed, covering the types and forms of tunnels, honeycombs, propellers, and power plants. The latter half of the section is devoted to descriptions, with illustrations, of the more important wind tunnels of the world. It is unfortunate that, although mentioned in a footnote, the full-scale wind tunnel of the National Advisory Committee for Aeronautics, at Langley Field, Va., could not be illustrated and that the figure illustrating the variable-density tunnel of the N.A.C.A. shows an arrangement which has been superseded.

The third section, of about 100 pages, by Professor Seiferth, of the California Institute of Technology, and Dr. A. Betz, of Göttingen, deals with the testing of airplane models in wind tunnels. This section begins with a discussion of similarity and then takes up successively the magnitudes to be measured and their representation, the types of balances and typical installations, the effects of the tunnel walls on the results, various details of testing and test equipment, and the lift and pressure distribution on certain wing sections. It concludes with a discussion of the influence of the Reynolds number on the lift and drag coefficients. These subjects are covered briefly but with surprising completeness in both text and figures, and the section lives up to what is expected of a handbook or manual.

The succeeding section, of about 30 pages, by Dr. Betz is devoted to a discussion of the determination of the forces and moments in the rotary motion of bodies (airplanes). This includes autorotation and spins of various types. The theoretical side is developed briefly and tied to the experimental. A notable number of references are given.

A most interesting section entitled "The Experimental Data on Resistance Without Lift," by H. Muttray, of Göttingen, occupies about 100 pages. The methods for determining resistance, both full-scale and in the wind tunnel and naval tank, are described. This is followed by the presentation of data on the resistance of flat plates and various bodies, together with the effects of various conditions on resistance. The section concludes with a chapter discussing methods for decreasing resistance which is rich with curves and figures summarizing and comparing the data, and is also notable for the number of references.

The next section, "Drop Tests of Spheres and Plates," by L. Schiller, of Leipzig, occupies about 50 pages. It first takes up the study of the resistance encountered by falling spheres, cylinders, and circular plates for small Reynolds numbers from the theoretical standpoint, and then describes the apparatus used by some eight investigators and presents the results of their studies, mostly in tabular form. The section is completed by a briefer discussion of the similar phenomena associated with the same forms at higher Reynolds numbers.

The last section, of about 30 pages, is entitled "The Phenomena of Journal Friction and Lubrication," and was prepared by S. Kiesskalt, of Frankfort (Main). It is somewhat more condensed than the other sections, but in small compass the author covers the fundamentals of the subject, describes and illustrates the more important equipment for the study of journal friction, and discusses the results of tests as portrayed in curve form.

As in the other parts of this volume, there is no bibliography as such, and all references are given as footnotes on the pages where they occur. The indexes by names and by subjects are as carefully prepared as before. Part 2 lives up to the standard set by the previous parts of the volume and should be as useful as its predecessors.

Books Received in the Library

HOUSE DESIGN, CONSTRUCTION, AND EQUIPMENT. Edited by J. M. Gries and J. Ford. President's Conference on Home Building and Home Ownership, Washington, 1932. Cloth, 6 × 9 in., 325 pp., illus., diagrams, tables, $1. The program for raising the standard of American housing adopted last December by the President's Conference on Home Building and Home Ownership has resulted in reports by committees of experts upon various aspects of the problem. The present report, which discusses the important questions of design, construction and equipment, is the work of committees composed of well-known architects, engineers, and home economists from all parts of the country, and the recommendations are based upon practical experience with existing conditions. The reports discuss the essentials of good practice, advocate better coordination of effort in the building trade, and indicate how building costs may be lowered to the advantage of the wage earner. The volume contains much useful information for architects and builders and prospective owners.

HANDBUCH DER GEOPHYSIK. Edited by B. Gutenberg. Band 9, Lieferung 1: Der Aufbau der Atmosphäre; Die Schallausbreitung in der Atmosphäre, by B. Gutenberg; Wärmehaushalt der Stratosphäre, pt. 1, by J. Tichanowski, pt. 2, by R. Mügge. Berlin, Gebrüder Borntraeger, 1932. 171 pp., illus., 7 × 11 in., paper, subscrip. price 24 r.m.; single price 36 rm. These monographs form the first part of a comprehensive summary of our knowledge of atmospheric physics. The structure of the atmosphere, the propagation of sound, and the phenomena of heat absorption and radiation in the stratosphere are discussed and the available numerical data presented.

INDEX TO THE LITERATURE OF FOOD INVESTIGATION. Vol. 4, No. 1, March, 1932. Department of Scientific and Industrial Research, London,

Great Britain. Paper, 6 × 10 in., 135 pp., 2s. 6d. (Obtainable from the British Library of Information, 270 Madison Ave., New York, $0.70.) This index, which appears every six months, is useful to all those concerned with food production and preservation. Nearly one hundred periodicals are covered, the entries are classified conveniently, and annotations are provided. Engineers will find the engineering section useful as a bibliography of investigations of refrigeration and air conditioning.

MACRAE'S BLUE BOOK, consolidated with Hendricks' Commercial Register. Fortieth Annual Edition. MacRae's Blue Book Co., Chicago and New York, 1932–1933. Cloth, 9 × 11 in., 3333 pp., illus., $15. A buying guide for manufacturers, railroads, mines, municipalities, public utilities, contractors, engineers, and mills. Materials are carefully classified and a good index is provided. There is also a directory of manufacturers and local distributers, a section describing the trade facilities in towns of more than one thousand inhabitants, and a directory of trade names. A section is devoted to Canada.

MITTEILUNGEN AUS DEN FORSCHUNGSANSTALTEN DES GHH-KONZERNS, Vol. 2, Heft No. 2, July 1932. V.D.I. Verlag, Berlin. Paper, 9 × 12 in., pp. 35–56, illus., diagrams, charts, tables, 2.50 r.m. This number includes a description of a new spectrum photometer and its use for the rapid analysis of alloys, especially iron; an article on the resistance of welded bars, a comparison of the calculated resistance of ships with the results of tests on models, and an essay on entropy and probability.

MODERN MATERIALS HANDLING. By S. J. Koshkin. John Wiley & Sons, New York, 1932. Cloth, 6 × 9 in., 488 pp., illus., diagrams, charts, tables, $6. This book brings together in convenient form a large amount of condensed information upon modern methods and equipment for handling materials in factories. Cranes, overhead transporters, trucks, conveyors, hoists, coal and ash handlers, etc., are considered. Methods of handling different materials are explained, and the choice of equipment for any given purpose is discussed.

MODERN PHYSICS. By G. E. M. Jauncey. D. Van Nostrand Co., New York, 1932. Cloth, 6 × 9 in., 568 pp., illus., diagrams, charts, tables, $4. In this textbook, which is intended for the student who has had one year of college physics and mathematics, his attention is directed to X-rays, the quantum theory, cosmic rays, relativity, radioactivity, astrophysics, and similar topics. The book is designed to give the student some knowledge of the parts of physics which are now in process of active formation or have only recently been developed.

NATIONAL ASSOCIATION OF COST ACCOUNTANTS YEAR BOOK 1932. The Association, New York. Cloth, 6 × 9 in., 320 pp., illus., diagrams, charts, tables, $3. The 1932 convention of this association was devoted to consideration of the trend of future industrial management in America, the type of organization that would be called for, and the responsibilities of the accounting department to the departments in charge of sales, finance, engineering, manufacturing, purchasing, etc. The papers and discussions upon these subjects are presented in this volume.

PRINTING TRADES AND THEIR WORKERS. By F. E. Clark. International Textbook Co., Scranton, 1932. Cloth, 5 × 8 in., 132 pp., illus., tables, $1.40. This monograph is intended as a guide to young people who are considering printing as a vocation. The scope of the printing industry, the work of the compositor, pressman, binder, stereotyper, photoengraver, and other craftsmen is simply, yet admirably described, and the qualifications necessary for each occupation, the opportunities, and rewards are discussed.

PROFITS OR PROSPERITY? By H. P. Fairchild. Harper & Brothers, New York and London, 1932. Cloth, 6 × 9 in., 204 pp., $2.75. According to this distinguished sociologist, the cause of the paradox of poverty in the midst of plenty is "the unrestrained struggle for profits in an economic system where general and unlimited profits, particularly money profits, are mathematically impossible." Here he traces where profits go and why their present distribution hampers the ordinary flow of trade and consumption, and proposes solutions of the difficulty.

PROTECTIVE FILMS ON METALS. By E. S. Hedges. D. Van Nostrand Co., New York, 1932. Cloth, 6 × 9 in., 276 pp., illus., diagrams, charts, tables, $5. This monograph aims to summarize our knowledge of the theory of corrosion of metals and of the methods by which it can be prevented. The mechanism of corrosion, the properties and examination of natural and artificial protective films, passivity, and anodic films are first discussed, after which the practice of protective coating is considered. Accounts are given of the protection of metals by hot dipping, electroplating, spraying, cementation, painting, etc. The book reviews the processes concisely, but comprehensively.

SIMPLE AERODYNAMICS AND THE AIRPLANE. By C. C. Carter. Fourth revised edition of the original work by C. N. Monteith. Ronald Press Co., New York, 1932. Cloth, 6 × 8 in., 594 pp., illus., diagrams, charts, tables, $4.50. This textbook has developed from the short course in aeronautics given to all cadets at the U. S. Military Academy, and is intended for use in elementary courses in engineering colleges. The fundamental principles are presented and applied with a considerable amount of descriptive matter, sufficient to equip the student for further work. The new edition has been thoroughly revised and partly rewritten.

WINDEN UND KRANE, Aufbau, Berechnung und Konstruktion. Heft 6. By R. Hänchen. J. Springer, Berlin, 1932. Paper, 8 × 11 in., pp. 401–495, illus., diagrams, charts, tables, 8 r.m. This section completes this useful work on crane design and construction. The present part is devoted to traveling cranes and to various kinds of special cranes, such as those for harbors and shipyards, railway cranes, cranes for blast furnaces and rolling-mills, and for shops.

Recent Advances in Physics

(Continued from page 79)

X-ray type, originating during the birth of atoms in interstellar space, and some regard them as neutrons, that is, entities comprising a proton and an electron traveling together in close proximity. Whatever may be their nature, we know that they possess enormous energy. They can travel through several feet of lead without complete absorption, and, in fact, we have reason to believe that they possess energies comparable with that which would be given to an electron in a fall through a potential difference of a thousand million or even ten thousand million volts. The passage of these cosmic rays through matter occasionally produces atomic disintegration which can be observed. It is hardly likely that the cosmic rays will provide a tool for the production of appreciable amounts of atomic disintegration. They do, however, provide a means for the study of such phenomena under conditions of extraordinarily high bombardment energy, energy such as only our fondest dreams could realize in the laboratory.

And so physics is well launched upon the next great stage in its attack upon the mysteries of nature. The nucleus has withstood assault for many years, but in the experiments of Cockcroft and Walton the physicist has already tasted the blood of conquest. Bigger guns are being built for the attack, and who knows but that in time we may realize in a practically usable sense the dream of the alchemists, the transmutation of the elements, and with it the still more dramatic hope, the utilization of atomic energy in the service of mankind.

Transoceanic Flying

(Continued from page 110)

2000 ft, and was thus enabled to keep above the clouds until evening. At about 6 p.m. the previously charted storm area was reached, and for from 8 to 10 hours the ship was in complete obscurity.

In describing this experience, Lotti writes, "We were in an unending succession of aerial acrobatics. We

were whirling dizzily or dropping suddenly. Once we fell from 10,000 ft to 1000 ft." Experiences of this sort compelled an immediate effort to rise to a safer altitude, all at a cost of precious fuel. After passing through the storm the voyagers came into a clearer region and were able to find their location by celestial observations.

They had intended to keep on the steamer lane, but because of the depleted fuel supply the course was directed to the Azores. Their location was next determined as 39½ N 28 W, whereupon, their gasoline seeming to be sufficient, the course was laid to Cape Finisterre. The landing was made on the south shore of the Bay of Biscay 34 miles west of Santander, with tanks nearly empty and the radiator almost dry.

What many regard as the greatest of all transoceanic flights was the westward crossing by Costes and Bellonte in 1930. The distance covered probably exceeded 4800 miles in 37 hr 18 min. It was the first, and up to now the only, non-stop flight from continental Europe to the United States. It is most interesting from the meteorological point of view since it utilized the wind currents to the north and west of a tropical hurricane, and nearly came to disaster in a local storm over Nova Scotia. The winds were favorable, easterly, over most of the course—a very unusual circumstance.

The comments by Costes are very illuminating and make a fitting close to this brief account of Atlantic weather experience. The thing that impressed him most was the radio. He says, "From the French coast until we made a landfall in America, we were in constant touch with ships or land stations." He regards it as of like order in importance to the motor, and he credits Kingsford-Smith for impressing him with the necessity of radio communication before his final preparations were completed. He also says:

> Had we determined to fly the direct course we should have been defeated. I compute that we lost in side trips to avoid storms or to find favorable winds about 600 miles. All this went to convince us that there is no route that can be determined in advance that would be best under all circumstances for a transatlantic flight. Weather conditions determine everything. Future flights, though they may be run on a schedule fixed in advance, will never be on a predetermined course. And finally, if others who have attempted to fly from Europe to America have failed, the chances are that it was because of lack of adequate preparation. I cannot stress this too much. Others have taken off with an excess of courage and a lack of reflection.

The great French pilot might well have said the same about some who have attempted the eastward crossing.

New York Safety Conference in March

THE Fourth Annual New York Safety Conference will be held at the Hotel Pennsylvania, New York City, March 1 and 2, under the auspices of the Metropolitan Chapter of The American Society of Safety Engineers, Engineering Section, the National Safety Council, and many other bodies, including the Metropolitan Section of the A.S.M.E. There will be sixteen sessions, those in the morning beginning at ten o'clock and those in the afternoon at 2:15. There will be no registration or admission fee to any of the sessions. Papers of particular interest to engineers include, "Employee Training Methods," by J. O. Keller, head of the department of engineering extension, The Pennsylvania State College; "The Conference Method," by C. T. Schrage, engineer, American Telephone and Telegraph Co.; "Elimination of Eye Hazards Through Engineering Revision," by C. P. Tolman, Mem. A.S.M.E. There will be an entire session on safety as applied to public utilities, as well as discussions of ventilation problems in industry and how small industries can organize a safety program.

A.S.M.E. Nominating Committee

THE 1933 Nominating Committee asks for suggestions of names of men qualified to fill the offices of President, Vice-President, and Manager of the Society. These names should be sent promptly to the Secretary of the Committee so that the Nominating Committee may give thorough consideration to them prior to the A.S.M.E. Semi-Annual Meeting in Chicago, June 25–30, 1933. The Committee will hold open sessions at Chicago to receive oral suggestions.

The selection of Society officers is an important task, and the Nominating Committee asks the cooperation of the individual members of the Society in guiding the Committee.

Officers should be men of prominence and leadership, with time to devote to Society affairs. Previous service on committees and consequent knowledge of Society affairs is a factor of importance.

The President and Vice-Presidents must be of the member grade. Other nominations may be of any grade of membership. Suggestions may be sent to the Secretary of the Committee.

T. L. WILKINSON, *Chairman*,
W. R. WOOLRICH, *Secretary*,
University of Tennessee, Knoxville, Tenn.

Candidates for Membership in the A.S.M.E.

The application of each of the candidates listed below is to be voted on after February 25, 1933, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references.

NEW APPLICATIONS

BROWN, C. K., Boston, Mass.; CHAPMAN, EVERETT, Coatesville, Pa.; CHAWLA, S. H., Lahore, India; COMPTON, KARL T., Cambridge, Mass.; DAVIS, C. A., JR., Peoria, Ill.; FARRELL, J. M., Hays, Kan.; HARKINS, H. DRAKE, Wilmington, Del. (Rt); HEINZE, WM. A., Chicago, Ill.; HOOPER, ANDREW J., Houston, Tex.; KUENEMANN, WESLEY A., Dallas, Tex.; LARSON, NORMAN F., East Hartford, Conn.; LUBELL, HERMAN, Brooklyn, N. Y.; MADHAVAN, K. O., Madras, India; MARSHALL, S. W., JR., Dallas, Tex.; MORSE, LOUIS S., JR., Washington, D. C.; PALTZ, ROBERT C., Flushing, L. I., N. Y.; PETERSON, MARTIN H., Brooklyn, N. Y.; PINKHAM, BURTON N., Fargo, N. D.; RENEHAN, MICHAEL J., New York, N. Y.; SCOTT, CURTIS R., West Newton, Mass.; SINGER, SIDNEY C., JR., Ann Arbor, Mich.; TOZER, SYDNEY J., Chicago, Ill.; VALENTINE, C. IRVING, Los Angeles, Calif.; VISCARDI, JOHN E., New York, N. Y.; WAIT, JUSTIN F., New York, N. Y.; WARNER, A. L. D., Los Angeles, Calif.; WYATT, C. C., San Francisco, Calif.

CHANGE OF GRADING

Transfers from Associate-Member:

CONLON, WM. T., New York, N. Y.; O'BRIEN, JAS. K., Philadelphia, Pa.; SCHLICK, LOUIS F., Camden, N. J.; VOLL, WALTER C., Istanbul, Turkey; WILLHELM, OSCAR F., Irvington, N. J.

Transfers from Junior:

BELL, THOS. E., Atlanta, Ga.; BURTT, NELSON W., Buffalo, N. Y.; CALDWELL, EUGENE, Milwaukee, Wis.; LAEMLE, MILTON M., Berlin, Germany; AMOROSI, GUIDO J., New York, N. Y.